FANUC Robot series

R-30*i*A/R-30*i*A Mate CONTROLLER

Robot Link

OPERATOR'S MANUAL

B-82924EN/01

- **Original Instructions**

Before using the Robot, be sure to read the "FANUC Robot Safety Manual (B-80687EN)" and understand the content.

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Further, re-export to another country may be subject to the license of the government of the country from where the product is re-exported. Furthermore, the product may also be controlled by re-export regulations of the United States government.
Should you wish to export or re-export these products, please contact FANUC for advice.

In this manual we have tried as much as possible to describe all the various matters.
However, we cannot describe all the matters which must not be done, or which cannot be done, because there are so many possibilities.
Therefore, matters which are not especially described as possible in this manual should be regarded as "impossible".

SAFETY

1 SAFETY PRECAUTIONS

This manual contains safety precautions against injury and property damage. Those precautions are labeled "Warning" or "Caution," according to the degree of importance. Supplementary explanation is given under "Note." Before starting to use a robot, carefully read the "Warning," "Caution," and "Note."

> ⚠ **WARNING**
> Failure to follow the instruction given under "Warning" can cause fatal or serious injury to the user. This information is indicated in bold type in a box so that it can be easily distinguished from the main body of this manual.

> ⚠ **CAUTION**
> Failure to follow the instruction given under "Caution" can cause injury to the user or property damage. This information is indicated in a box so that it can be easily distinguished from the main body of this manual.

> **NOTE**
> The information given under "Note" is a supplementary explanation, which is neither a warning nor a caution.

Carefully read and save this manual.

1.1 WORKERS

A robot cannot do anything alone. The robot can operate only after it is equipped with a hand or other device and connected with peripheral equipment to form a system.
Give considerations for the safety of not only the robot but also the entire system. When using the robot, provide a safety fence and other safety measures. FANUC defines the system personnel as indicated below. Check which worker should be trained in a specialist robot course.

Operator

The jobs of an operator are:

- Turning on and off the system
- Starting and stopping programs of a robot
- Recovering the system from an alarm state

The operator must not enter the area enclosed by the safety fence to do his or her work.

Programmer or teaching operator

The jobs of the programmer or teaching operator include the jobs of the operator and the following:

- Teaching of a robot, adjustment of the peripheral equipment, and other work that must be done in the area enclosed by the safety fence

The programmer or teaching operator should be trained in a specialist robot course.

Maintenance engineer

The jobs of the maintenance engineer include the jobs of the programmer and the following:

- Repair and maintenance of the robot

The maintenance engineer should be trained in a specialist robot course.

1.2 GENERAL SAFETY PRECAUTIONS

This section lists general safety precautions. Before starting to use the robot, read the precautions. The subsequent sections of the manual indicate other precautions. Take each of the precautions.

General rules

⚠ WARNING

1 When the robot is used, the following precautions should be taken. Otherwise, the robot and peripheral equipment can be adversely affected, or workers can be severely injured.
- Avoid using the robot in a flammable environment.
- Avoid using the robot in an explosive environment.
- Avoid using the robot in an environment full of radiation.
- Avoid using the robot under water or at high humidity.
- Avoid using the robot to carry a person or animal.
- Avoid using the robot as a stepladder. (Never climb up on or hang from the robot.)

2 Robot personnel must wear the following safety articles:
- Clothing suitable for each job
- Safety shoes
- Helmet

NOTE

Programmers and maintenance staff should be trained in a suitable course at FANUC.

Notes on installation

⚠ WARNING

The robot should be transported and installed by accurately following the procedures recommended by FANUC. Wrong transportation or installation may cause the robot to fall, resulting in severe injury to workers.

⚠ CAUTION

In the first operation of the robot after installation, the operation should be restricted to low speeds. Then, the speed should be gradually increased to check the operation of the robot.

Notes for Mechanism

NOTE

1 Keep the component cells of the robot system clean, and operate the robot in an environment free of grease, water, and dust.
2 Use mechanical unit cable that have required user interface.
Please do not obstruct the movement of the mechanical unit cable when cables are added. (Please never do the nylon band stop etc. of an external cable to the mechanical unit cable.) Moreover, please do not interfere with the mechanical unit cable when equipment is installed in the robot. If these precautions are not observed there is a possibility that the mechanical unit cable is disconnected and the trouble not anticipated occurs.
3 Employ a limit switch or mechanical stopper to limit the robot motion so that the robot or cable does not encounter its peripheral devices or tools.

Notes on operation

⚠ **WARNING**

Before the robot is started, it should be checked that no one is in the area of the safety fence. At the same time, a check must be made to ensure that there is no risk of hazardous situations. If detected, such a situation should be eliminated before the operation.

⚠ **CAUTION**

Operators should be ungloved while manipulating the operator's panel or teach pendant. Operation with gloved fingers could cause an operation error.

NOTE

Programs, system variables, and other information can be saved on external storage. Be sure to save the data periodically in case the data is lost in an accident. (See the file input/output section for saving the data.)

Notes on programming

⚠ **WARNING**

Programming should be done outside the area of the safety fence as far as possible. If programming needs to be done in the area of the safety fence, the programmer should take the following precautions:

- Before entering the area of the safety fence, ensure that there is no risk of dangerous situations in the area.
- Be prepared to press the emergency stop button whenever necessary.
- Robot motions should be made at low speeds.
- Before starting programming, check the entire system status to ensure that no remote instruction to the peripheral equipment or motion would be dangerous to the user.

⚠ **CAUTION**

After programming is completed, a text execution should be given according to a specified procedure. (See the section of program execution on this manual). During the text execution, workers must stay out of the safety fence.

NOTE
Programmers should be trained in a suitable course at FANUC.

Notes on maintenance

⚠ **WARNING**

1 During maintenance, the robot and system should be in the power-off state. If the robot or system is in the power-on state, a maintenance operation could cause a shock hazard. If necessary, a lock should be provided to prevent any other person from turning on the robot or system. If maintenance needs to be executed in the power-on state, the emergency stop button should be pressed.
2 When replacing a part, please contact FANUC service center. If a wrong procedure is followed, an accident may occur, causing damage to the robot and injury to the worker.
3 When entering the area enclosed by the safety fence, the maintenance worker should check the entire system to make sure that no dangerous situations are present. If the worker needs to enter the area of the fence while a dangerous situation exists, the worker should always take extreme care and check the current system status.
4 A part should be replaced with a part recommended by FANUC. If other parts are used, malfunction or damage would occur. Especially, a fuse that is not recommended by FANUC should not be used. Such a fuse may cause a fire.
5 When a motor or brake is removed, the robot arm should be supported with a crane or other equipment beforehand so that the arm would not fall during the removal.
6 If a robot motion is necessary during maintenance, the following precautions should be taken:
   - Reserve an escape route. During the maintenance, always check the motions of the whole system so that the escape route will not be blocked by the robot or peripheral equipment.
   - Always pay attention to risk of dangerous situations and get prepared to press the emergency stop button whenever necessary.
7 When a motor, decelerator, or other heavy load is handled, a crane or other equipment should be used to protect maintenance workers from excessive load. Otherwise, the maintenance workers would be severely injured.

⚠ CAUTION

1 Whenever grease is spilled on the floor, it should be removed as quickly as possible to prevent dangerous falls.
2 The robot should not be stepped on or climbed up during maintenance. If it is attempted, the robot would be adversely affected. In addition, a misstep can cause injury to the worker.
3 The following parts are heated. If a maintenance worker needs to touch such a part in the heated state, the worker should wear heat-resistant gloves or use other protective tools.
   - Servo motor
   - Inside the control unit
4 When a part is replaced, all bolts and other related components should put back into their original places. A careful check must be given to ensure that no components are missing or left unmounted.
5 Before the maintenance of the pneumatic system is started, the supply pressure should be shut off and the pressure in the piping should be reduced to zero.
6 After a part is replaced, a text execution should be given for the robot according to a predetermined method. (See the program execution of this manual.) During the text execution, the maintenance staff should work outside the safety fence.
7 After the maintenance is completed, spilled oil or water and metal chips should be removed from the floor around the robot and within the safety fence.
8 When a part is replaced, care must be taken to prevent dust from entering the robot.

NOTE

1 Each maintenance worker or inspection worker should be trained in a suitable course at FANUC.
2 Maintenance should be done under suitable light. Care must be taken that the light would not cause any danger.
3 The robot should be periodically inspected. (Refer to the controller and mechanical manual.) A failure to do the periodical inspection can adversely affect the performance or service life of the robot and may cause an accident.

1.3 SAFETY PRECAUTIONS

Safety precautions

Unlike ordinary automatic machines, robots have arms and wrists, which can be moved, in all operation space. A robot is quite flexible, but on the other hand, it is quite dangerous. The robot is usually connected with peripheral equipment to comprise an automated system. Users must take safety precautions for the entire system.
The safety precautions are described below.

Safety precautions related to installation and layout

- Use warning lamps and other provisions to indicate that the robot is operating.

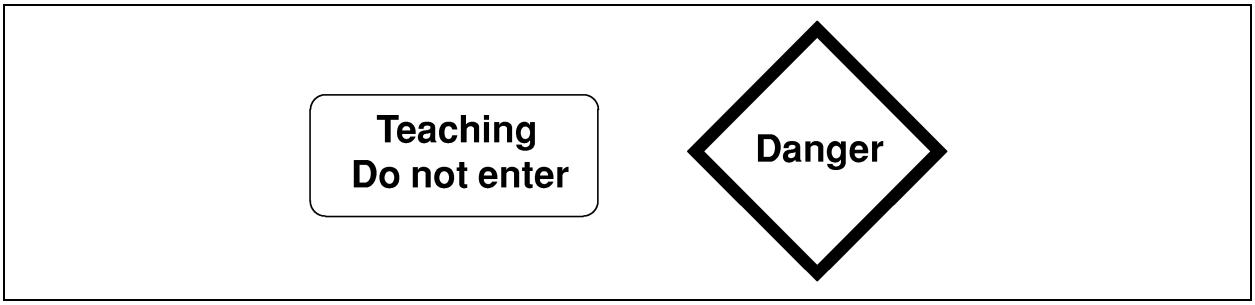

Fig. 1.3 (a) Alarm Indications

- Put a protective fence with safety door around the system so that only the operator can enter the operating area by the door. Design the system so that it will stop when the door is opened.

NOTE
Connect the *EAS1, *EAS11, *EAS2, *EAS22 (*FENCE1, *FENCE2 for single chain controller) input signal to the safety door. Refer to the controller maintenance manual for explanations about how to connect.

- Put a protective fence so that the motion range of the robot is surrounded completely. Moreover, put the controller outside of the protective fence.

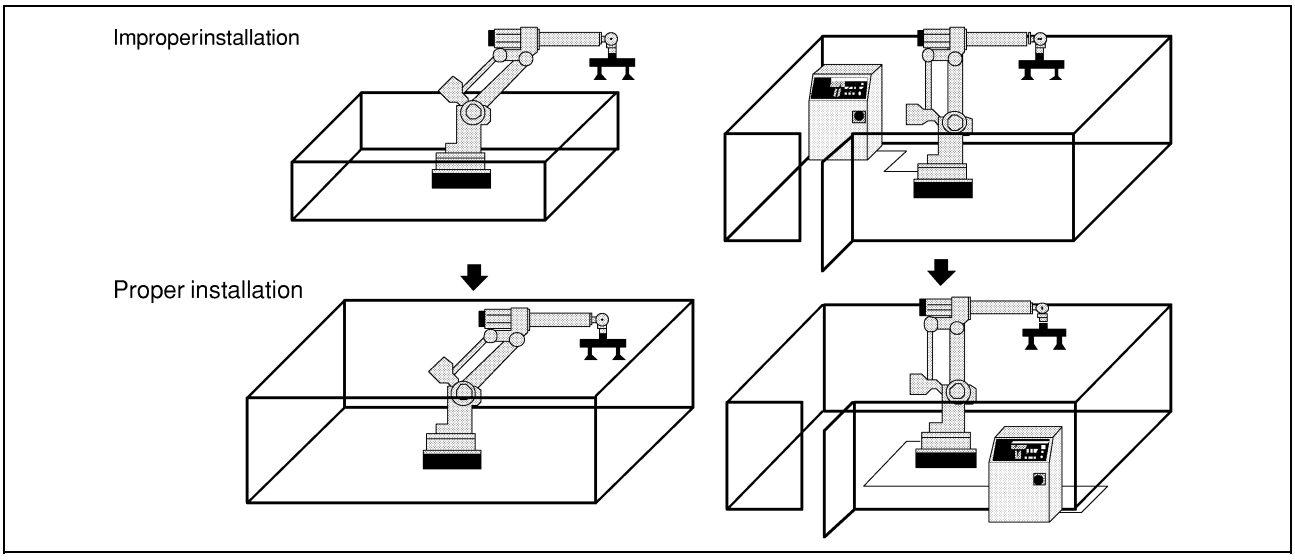

Fig. 1.3 (b) Safety fence

- Install an emergency stop button where it will be readily accessible to the operator.

NOTE
Upon receiving an emergency stop signal, the controller immediately stops the robot.

Safety precautions related to system design

- Install a safety joint between robot wrists. If an abnormal external force is applied to the robot, the safety joint breaks and the robot stops.

NOTE
When the hand break (*HBK) input signal goes off, the controller immediately stops the robot.

- Hand breakage detection can be disabled when the *HBK input signal is off. This can be set on the system setting screen. See the section of the system config menu.
- Ground all peripheral units properly.
- When a desired operating area is smaller than the maximum operating area of the robot, the desired area can be specified by parameters.
- The robot receives interlock signals sent from remote equipment. Upon receiving a signal indicating the operating status of the remote equipment, the robot can stop or halt.
- When required, install a lock so that only authorized personnel can switch the power on.

NOTE
The circuit breaker on the control unit door is designed such that power-on can be disabled by setting a padlock.

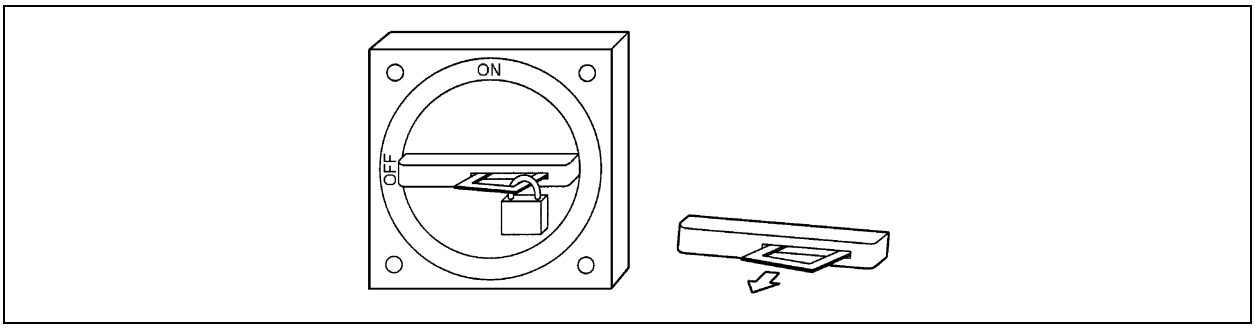

Fig. 1.3 (c) Locking the Circuit Breaker

Safety precautions related to inspection and maintenance

- Before starting the inspection or maintenance, turn off the controller. Lock the circuit breaker or place a guard to prevent someone else from switching the power on.
- Before disconnecting the pneumatic system, release the supply pressure.
- Before starting an inspection in which the electrical system of the robot need not be operated, press the emergency stop button.
- When carrying out an inspection in which the robot needs to be operated, carefully observe the motion of the robot. Immediately press the emergency stop button whenever required.

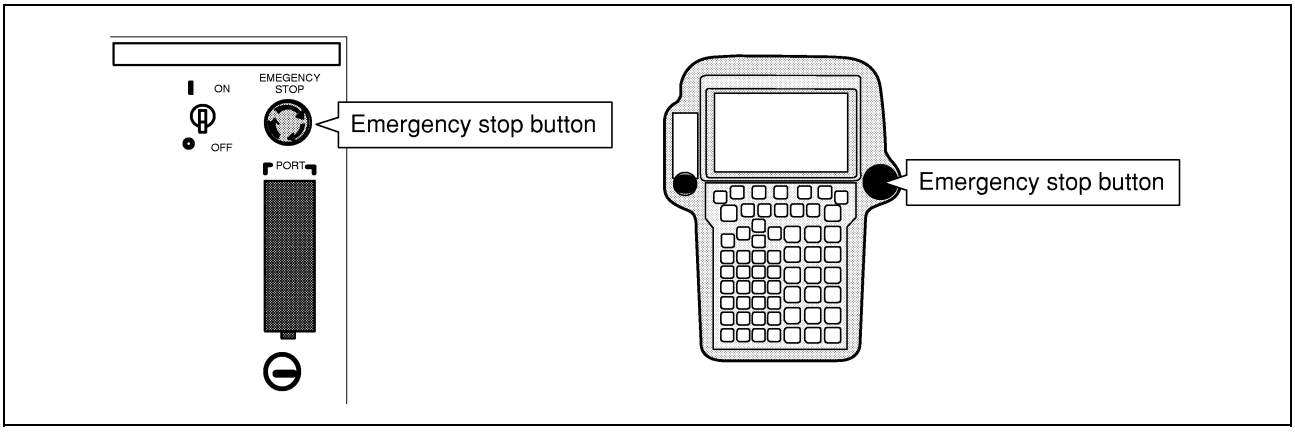

Fig. 1.3 (d) Emergency Stop Button

Safety precautions related to transportation

- When carrying the robot or another unit on a carrier such as a crane or forklift, securely fasten the robot to the carrier.
- Carefully inspect the crane, forklift, other carrying equipment, and carrying handle on the product.

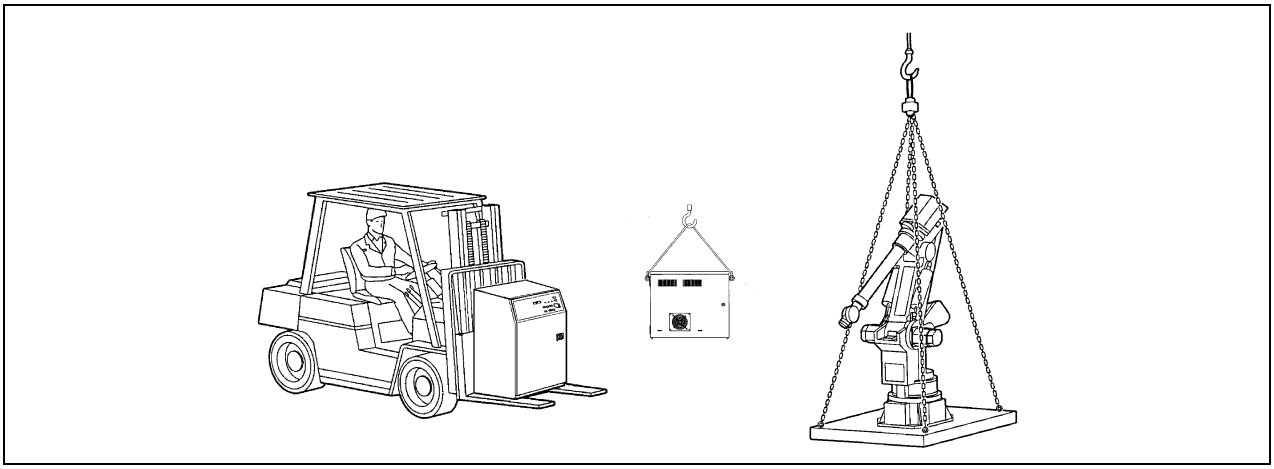

Fig. 1.3 (e) Carrying the Robot

Safety precautions related to operation

- All robot system operators are requested to attend FANUC training courses to learn the safety precautions and functions of the robot.
- Before beginning to program the robot, make sure that there are no abnormal or dangerous conditions around the robot and peripheral equipment.
- Before working within the operating area of the robot, even when the robot is not running, switch the power off or press the emergency stop button. Place a guard to prevent someone else from entering the operating area of the robot or activating the robot from the operator's panel.
- While programming the robot in its operating area, place a guard so that the robot can be immediately stopped in an emergency.

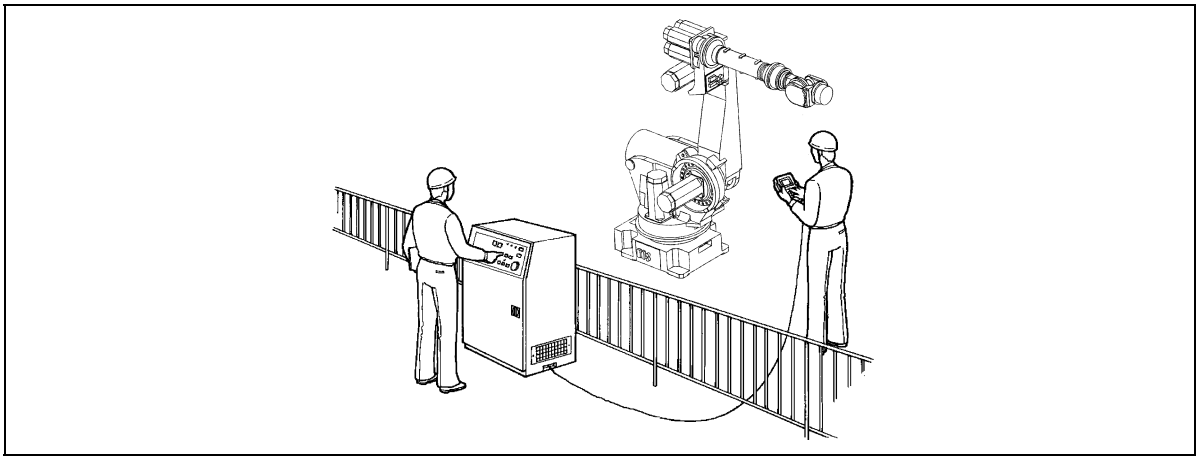

Fig. 1.3 (f) Danger Monitoring by Two Persons

Table 1.3 Safety precautions item

Operator	Workshop	Transportation and installation
Avoid dangerous behavior. Wear working clothes, safety shoes, and a safety helmet.	Keep the workshop neat, tidy, and clean. Install a protective fence and warning indications. Provide ventilation. Never bring flammable material to the workshop.	Keep the transportation lane free from obstacles. When carrying the robot or another unit on a carrier such as a forklift or crane, securely fasten it to the carrier. Keep a sufficient operating area. Make connection s properly.
Operation	**Maintenance and inspection**	**Hand**
Attend training classes. Master the operating procedures. Exclude unauthorized personnel.	Use only FANUC products for repair. Before starting maintenance or inspection, turn the power off. Close the controller door.	Inspect and take care of cables. Check the pneumatic pressure. Inspect the hand mechanism.

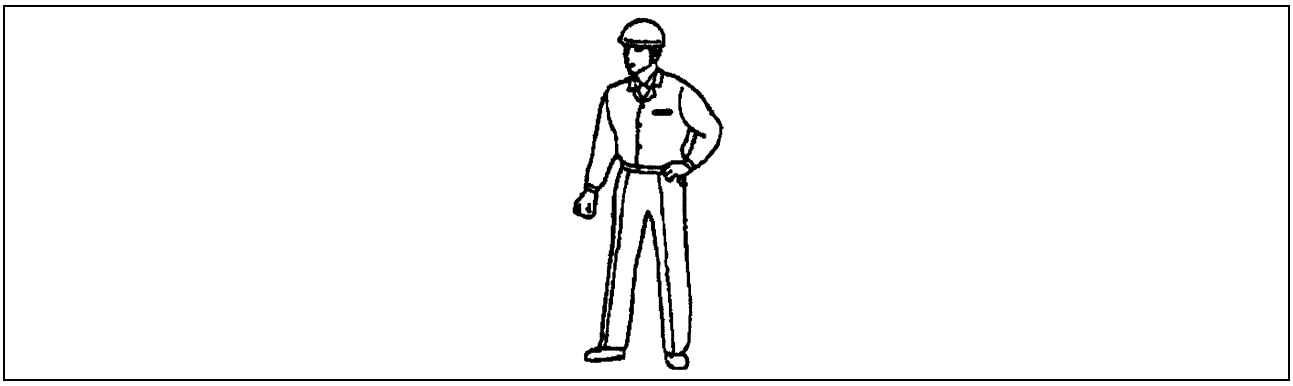

Fig. 1.3 (g) Safety Clothes and Safety Helmet

- Before approaching the robot to program it, hold the teach pendant in your hand, press the deadman switch, and set the teach pendant enable switch on.

NOTE
If the deadman switch is released while the teach pendant enable switch is on, the robot immediately stops.

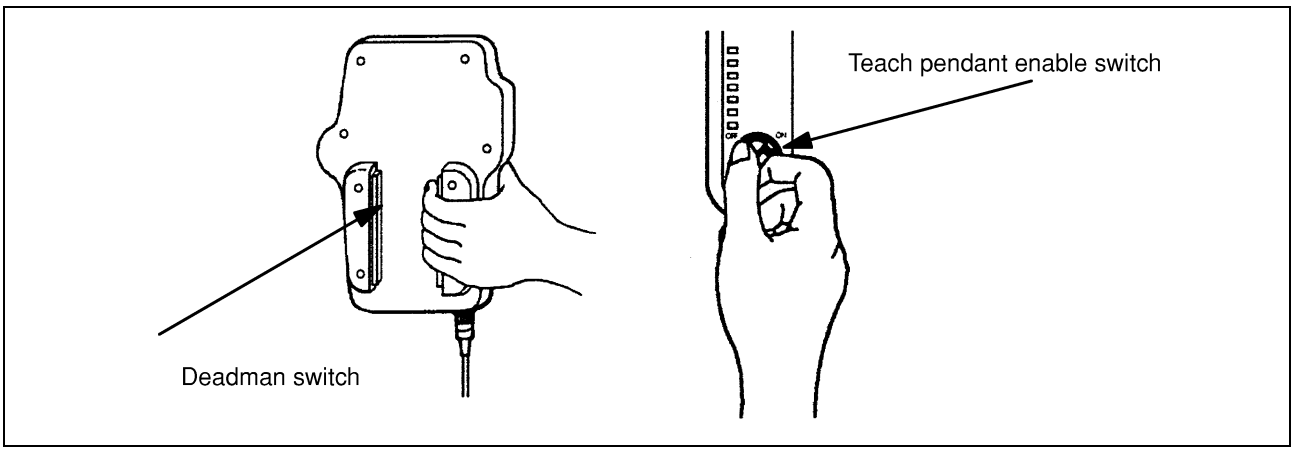

Fig. 1.3 (h) Deadman switch and Teach pendant enable switch

- Before moving the robot by jog feed, carefully observe the operation of the jog keys and the robot.
- Before moving the robot by jog feed, sufficiently lower the feedrate override of the robot.

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ADDITIONAL INFORMATION

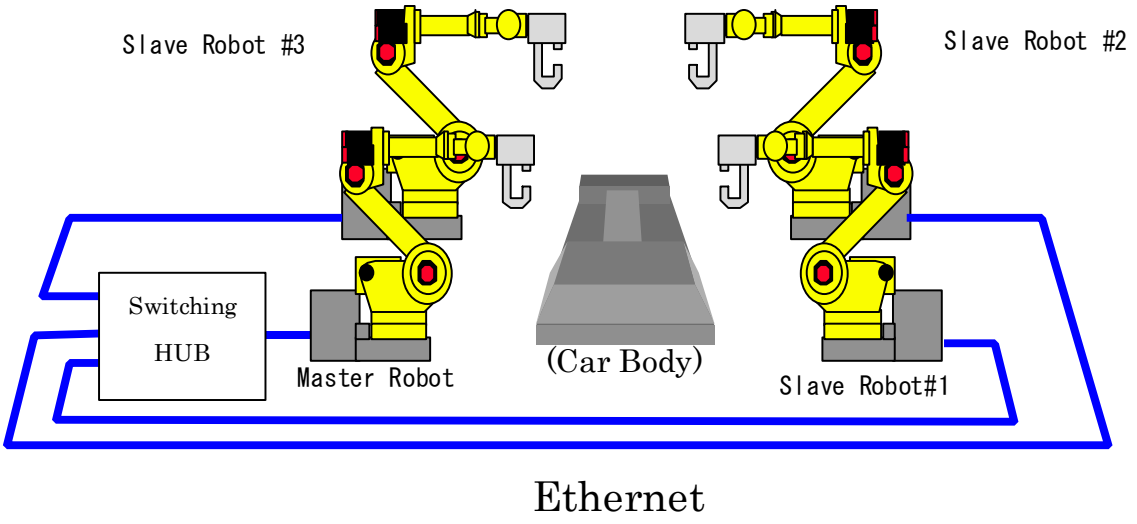
1 INTRODUCTION

This manual describes the setup and use of **Robot Link on R-30*i*A controllers** using V7.20P/20 or higher software. If your system uses older controller models (R-J3 or R-J3*i*B), Do NOT use this manual. You need to use an earlier version of the Robot Link User's Manual.

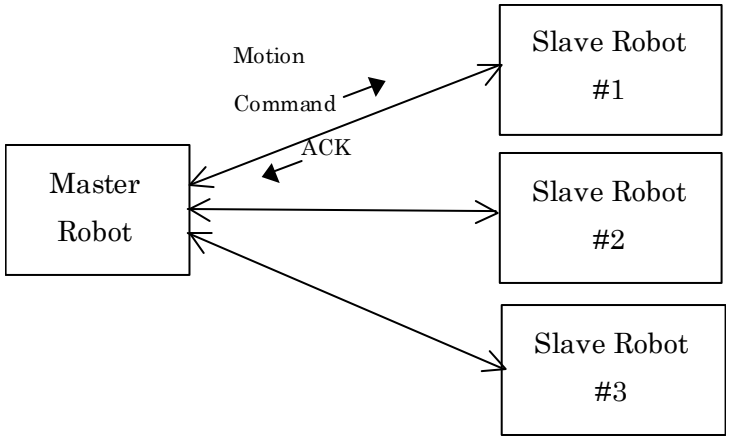
- This software enables several robots to perform synchronous motion between several controllers by Ethernet network. FANUC R-30*i*A robot controller has Ethernet hardware as a basic functionality.

1.1 OVERVIEW OF ROBOT LINK:

- Robot Link is an inter-controller motion control software package that uses Ethernet to send and receive motion information BETWEEN master and slave robot controllers. When Robot Link programs execute (one on the master and one on each slave controller) the slave motion path is executed with respect to the moving frame associated to the master TCP. The master controller coordinates motion between multiple robot arms so that heavy workpiece handling, beyond the limit for a single robot's capacity, is now available by this function.
- The master controller communicates between controllers by connecting each robot by an Ethernet (straight cable) through a switching HUB.



The master robot continuously sends motion information to the slave robots. The slave robots follow the master robot's motion and send ACK to master robot. The master robot, after receiving the ACK from the slaves, moves to next point and send next motion information. So, when noise or physical damage occurs to the communication line that stops communication, master and slave robots stop their motion as well. The figure below shows the communication scheme.



- Robot Link also supports remote jogging of slave robot(s) on one or more controllers with respect to the moving frame of the master group.

2 SOFTWARE LIMITATIONS

2.1 LIMITATIONS ON OTHER SOFTWARE OPTIONS

This function has the following restrictions.

> ⚠ **CAUTION:**
> If you don't obey the following restrictions, it is possible that robot moves to unexpected position.

This function cannot work correctly if one of the following optional software is ordered and installed to robot controller.

- Line Tracking (A05B-2400-J512)
- TAST (A05B-2400-J511)
- AVC (A05B-2400-J526)
- RPMP (A05B-2400-J532)
- AccuPath (A05B-2400-J631)
- Constant Joint Path (A05B-2400-J642)
- MIG EYE (A05B-2400-J700)
- Visual Tracking (A05B-2400-J721)
- Intelligent TP PC I/F (A05B-2400-J770)
- Integrated auxiliary axis is not supported with this function. You must not use integrated auxiliary axis with this function.

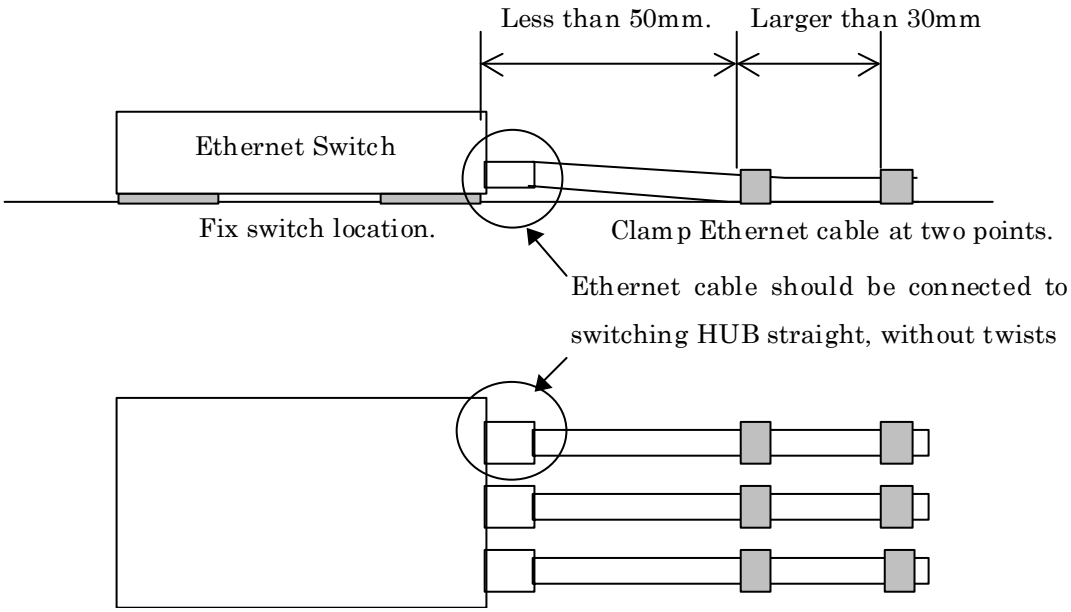
The following function must not be used in the synchronized Robot Link program of the slave robot.
- Touch Sensing (A05B-2400-J536)
- Enhanced User Frame (A05B-2400-J604)
- Space Check (A05B-2400-J609)
- Soft Float (A05B-2400-J612)
- Continuous Turn (A05B-2400-J613)
- Coordinated Motion (A05B-2400-J619)
- Remote TCP (A05B-2400-J624)
- FANUC Force Control (A05B-2400-J630)
- High Speed Skip (A05B-2400-J627)
- Error Recovery (A05B-2400-J664)

The following function must not be used in synchronized Robot Link program of the master robot.
- Touch Sensing (A05B-2400-J536)
- Space Check (A05B-2400-J609)
- Soft Float (A05B-2400-J612)
- Continuous Turn (A05B-2400-J613)
- High Speed Skip (A05B-2400-J627)
- FANUC Force Control (A05B-2400-J630)
- Error Recovery (A05B-2400-J664)

Please note that there might be some significant restrictions to using options not included in this list. Please contact FANUC Robotics regarding software options available and their level of operation in Robot Link systems and especially during robot link synchronized motion.

2.2 NETWORK

- Please use 10/100Base-T twisted pair Ethernet cable with noise shield.
- Please use an Ethernet switch to create collision free Ethernet 10/100Base-T network.
  FANUC recommends that you should use non-shield type RJ-45 connector both for cable and switch connector to avoid influence of the electronic noise on Ethernet trunk line.
- If the Robot Link system consists of two controllers, you can directly connect a straight or crossover cable between them. For three or more controllers, please use switching HUB and straight cables.
- Connection of Ethernet cable and switching HUB must be permanent
- The following figures are examples for reliable cable connection routing.



- Please refer to the specifications of the Ethernet switch and meet the environmental requirements for that device. For example, the switch should be installed in a stable and dustless location.
- Provide isolation and grounding as necessary to prevent electrical noise.

> The customer needs to purchase Ethernet cable, switching HUB and spare parts as necessary. High quality, industrial grade equipment is recommended. Stock spare parts as required.

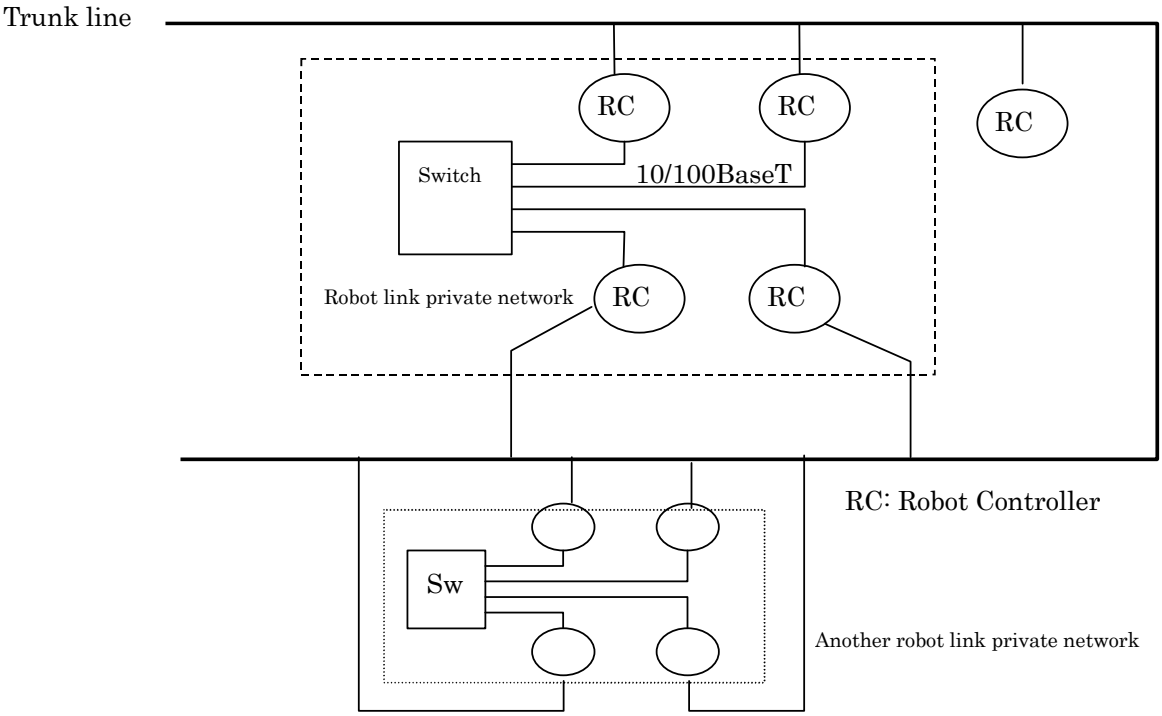
If you are using a mixture of controller versions, this communication model is required. Please refer to an earlier version of the Robot Link User's Manual.

2.3 NETWORK CONFIGURATION FOR R-30*i*A CONTROLLERS:

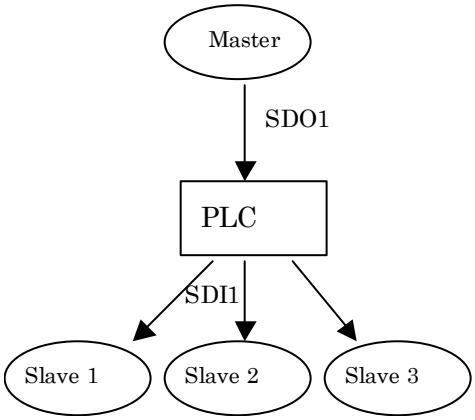
- The R-30*i*A controller provides two Ethernet ports on the CPU PC board. In prior controller versions, it was necessary to provide isolation of Ethernet ports from the factory Ethernet trunk during Robot Link operations. The "B" channel of the CPU is a high priority Ethernet port; this port is used to support the "private network" for Robot Link communication.

- The following figure is example of network configuration for robot link as supported on R-30*i*A controllers. The robot link network is configured on the high priority, channel B Ethernet line of the master and slave controllers. Trunk line communications are configured on the channel A line of the R-J3*i*C controller.

- Port A connects to the Trunk line; Port B is connected to the 10/100Base T switch in the Robot Link private network.



- In addition to Ethernet communication, robot link function uses a digital I/O line from master robot digital output to slave robot digital input. This digital I/O line is used to notify completion of the synchronous motion and the start of the next normal motion. Please install the following I/O lines.



- An alternative to using physical I/O would be to use Ethernet Global Data (EGD option) to provide the signal. EGD is an Ethernet packet transfer protocol that is implemented as digital I/O points transmitted periodically between controllers. The number of I/O points and communication rate are configured in the EGD I/O screen. EGD I/O can be mapped to Digital, UOP, and Group I/O. The Robot Link private network can support this protocol at the default rate. If the communication rate is raised, there may be an issue with collisions on the private network as the number of slaves is increased.

3 IMPORTANT SYSTEM INFORMATION (READ BEFORE USAGE)

The following important information must be understood and applied to your Robot Link System.

3.1 NETWORK CONFIGURATION

Please refer to the network configuration diagram above:

- Robot link private network should not be connected directly to Ethernet trunk line. It is possible that unexpected motion may occur if the re is an excessive number of collisions impacting throughput of robot link packets by FTP or other operations occurring on the Ethernet trunk line. The packets for robot link are broadcast type packets and may adversely effect the operation of the Ethernet Trunk line. Robot Link execution can consume a large amount of the Trunk line Ethernet capacity.
- Ethernet cable must be installed to avoid physical damage. For example, the Ethernet cable must not interfere with human operator or any other moving object in robot site.
- Please take enough countermeasures to prevent the electrical noise on Ethernet cable. Ethernet cable must not be allocated near to equipment that generates electronic noise.
- The power cord of Ethernet switch should not interfere with human operator or any moving object in robot site.
- The connection between Ethernet cable and Ethernet switch must be permanent. You should consider Ethernet cable routing and Ethernet switch installation as a permanent connection. If the connection is loose, then stable Ethernet communication is not possible. This will prevent robot synchronous motion from starting, or can cause current robot synchronous motion to stop, or prevent teaching robot positions in the synchronized slave robot program.
  This point is very important. Please be careful about this point.
  - You can confirm Ethernet cable connection by the amber LED which is mounted near the RJ-45 connector on R-J3*i*B main PCB. After you have connected Ethernet cable between robot controller and Ethernet switch, please cycle power of both robot controller and Ethernet switch. If the connection between robot controller and Ethernet switch is OK then the amber LED will turn on. If you have installed Ethernet cable and the switch correctly but the LED does not turn ON, then please contact to FANUC service center and report your problem to FANUC.
  - Normally, Ethernet switch has LEDs to show communication status on its front surface for diagnosis. Please check these LEDs when Ethernet communication problem occurs. The switch should be installed as you can see the LEDs easily for such diagnosis.
- If emergency stop, hold, or alarm stops one robot of robot link system, and then other robots in the robot link system should be stopped together. You should design remote control signals to meet this requirement.

3.2 PLC PROGRAMMING FOR ROBOT LINK SYSTEM FOR ROBOT LINK ROBOTS.

- Use the “Robot link status signal” in Multi-Arm setup screen. Please refer “4-3-3 Setup status signal” in this manual. This status signal turns ON automatically when the robot is in synchronous motion.
- If a robot in synchronous motion detects any input signal that causes emergency stop, the other robots should be stopped also as emergency stop. Please follow the next signal logic.

  - When EMGOUT signal of one robot in robot link network is ON, if other robots' "status signal" and PROGRUN (UO3) are both ON, then input External Emergency signal to the robots until

their PROGRUN output become all OFF. This check should be enabled at once after all PROGRUNs of all robots in robot link network are ON, and should be continued until the PROGRUNS are all OFF.

- When a robot in synchronous motion detects HOLD input, the other robots should be stopped by HOLD input. Please follow the next signal logic.

  - When PROGRUN output of a robot in robot link network is OFF, if other robots' "status signal" and PROGRUN (UO3) are both ON, then input *HOLD (UI2) to other robots until their PROGRUN output become all OFF.
    This check should be enabled at once after all PROGRUNs of all robots in robot link network are ON, and should be continued until the PROGRUNS are all OFF.

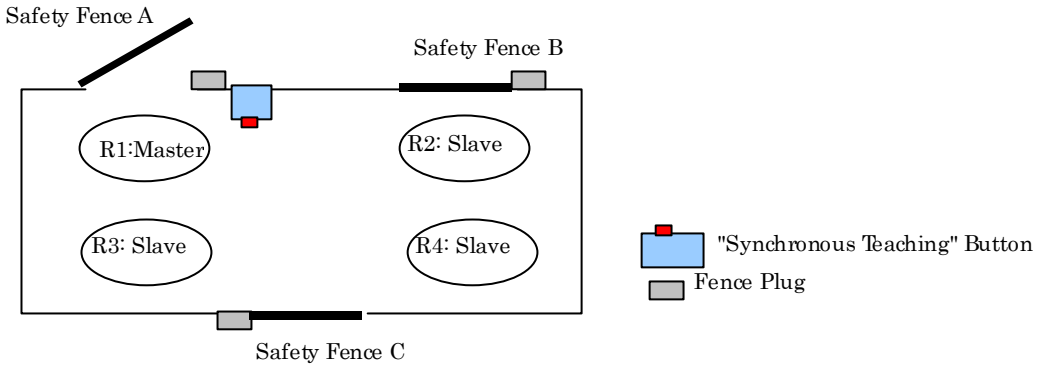
- When a robot detects an alarm to stop robot in synchronous motion, other robots should be stopped by emergency stop. Please follow the next signal logic.

  - When SYSRDY (UO2) output of a robot in robot link network is OFF, if other robots' "status signal" and PROGRUN (UO3) are both ON, then input External Emergency to other robots until their PROGRUN output become all OFF.
    This check should be enabled at once after all PROGRUNs of all robots in robot link network are ON, and should be continued until the PROGRUNS are all OFF.

- Alarms, which may occur in synchronous motion in production phase, are mostly servo OFF alarm. So we think this signal logic does not have any side effect for daily production.

3.3 CELL INTERFACE FOR TEACHING SYNCHRONOUS MOTION

Add a "Synchronous Teaching" button and the following signal control logic for the button to your system. This button should be located near the "safety fence A" which is close to master robot. Please see the following figure.



Robot link Synchronous teaching and jogging require that the master controller is in T1/T2 mode and the slave controllers are in AUTO mode. The method for supporting this is to devise a “local fence” circuit for the master robot and maintain a global fence for the slave robots. The Synchronous Teaching button makes a complete fence circuit for the slave robots by bypassing the signal around the master robot fence.

*FENCE and *SFSPD should be controlled by PLC according to the status of safety fence A and "Synchronous Teaching" button as the following tables.

Safety Fence A	Open	Close
*SFSPD(Normally ON)	OFF	ON

Safety Fence A	Open		Close	
Synchronous Teaching Button	ON	OFF	ON	OFF
*FENCE(Normally ON)	ON	OFF	ON	

If another fence is opened, *FENCE to the entire slave robot must be OFF to stop robots by FENCE alarm.

PLC must control the following signals when the "synchronous teaching" button is ON.
This is to limit that only master robot operator can control slave robots.

- If CMDENBL signal of slave robot is OFF (For example, TP is disabled, Remote switch is set to local, single step enabled, Disabled to move, etc), input external emergency signal or servo disconnect signal to stop the entire robot.

- Even if CMDENBL of slave robot is ON, program start by external signal must be disabled.

In the robot link system, regardless of the "Synchronous Teaching" button status, each robot's EMGOUT signal should be connected to the other robot's ESTOP input so that all the robots are stopped by any other robot's E-STOP or deadman-release event.

3.4 TEACHING PROCEDURE FOR ROBOT LINK PROGRAMS

Following is the procedure for teaching the robot link system. This is the minimal teaching sequence for single point Slave robot link slave Sub program. This information will be repeated in more detail in a later section. An additional slave Sub program type that supports multiple slave program positions is also covered.

- Before teaching slave program positions, the slave robot operator moves the slave robots to the synchronization start position. The operator exits from the safety fence and close the fence then disable TP on that slave robot controller.
- Once the slave robots are in the synchronization position, the master robot operator opens safety fence and pushes the "Synchronous Teaching" button ON. At this time all robots are in servo ON condition. Even though the "Synchronized Teaching" button is ON, if another safety fence is opened, PLC must stop all the robots by FENCE alarm.
- Master robot operator presses the reset button on TP to reset master robot's alarm status.
- To teach positions on the salve robots, the master robot must transmit its position to the slave robots. This is done in the Manual Function menu by selecting Robot Link, then set a link pattern, and finally press the “Master” softkey on the teach pendant. This operation is described later in this manual. This procedure is also used to initiate Robot Link jogging. In the robot link manual function screen, if master robot status is changed to "Master (Manual)", then master robot operator can perform Robot Link jogging.
  - If slave robots are in alarm status, by the "MASTER" button operation in master robot manual function screen, slave robots try to reset its alarm status. This case, master robot status in the manual function screen is displayed as "Link incomplete" at first. So please re-try the "MASTER" button. If the status is changed to "Master (Manual)", then Robot Link jog becomes available.
  - If slave robot cannot reset the alarm status by some alarm cause, master robot's status is kept to be "Link incomplete". In this case, please remove alarm cause from slave robot and retry.

- The master robot operator turns OFF the "Synchronous Teaching" button after teaching robot link program.

⚠WARNING
- "Synchronous Teaching" button should be ON only in robot link teaching operation.
- When the master robot operator is teaching a robot link program, the slave robot operator must be outside of the safety fence.

- RIA specification

  In case of RIA specification, the following steps must be added to the above operation.

  - ✓ When slave robot operator gets out of safety fence for robot link teaching, the slave robot must be set to AUTO mode.
  - ✓ **In RIA specification, deadman release event is not passed to EMGOUT signal. With deadman SW monitor (future optional functionality), please input External emergency signal servo disconnect signal to stop another robot from deadman switch.**

3.5 ABOUT SETUP

There are several terms and concepts and terms summarized below that are important for setting up and using the Robot Link system.

3.5.1 RIPE:

ROS **I**nter-processor **P**acket over **E**thernet is a global clock and data sharing mechanism over Ethernet. It is a protocol to support transfer of motion and process data and timing. This feature is setup by an XML file called ROSIPCFG.XML (see below)

- Ethernet channel B on the main CPU is a high priority link between robots in the Robot Ring (see definition below.) In addition to providing packet processing for motion data, error information, and program execution, the software provides system timing coordination for robots in the ring.
- A configuration file (ROSIPCFG.XML; see below) specifies the members of the ring. This file contains the names, IP addresses and order of the robots in the ring. All of the robots in the ring have the same robot ring configuration information.
- RIPE will automatically synchronize the master robot with other ring members on power up, but the ring can work with a member offline (providing no “across controller”) software depends on that controller such as EGD.

3.5.2 MASH:

Multi **A**rm **Sh**ell is a control mechanism to coordinate selecting and executing programs across multiple robot controllers. It also provides motion and process synchronization, single step coordination, and basic error recovery function. Finally it provides for common broadcast of SOP and TP control signals, and broadcast of alarms to all robots in the ring.

3.5.3 Robot Link:

Robot link is an inter-controller motion control mechanism. Under this motion control, the slave robot performs motion follows the master robot TCP frame. The master robot frame is sent via Ethernet to the

slave robot every ITP. The slave calculates the offset from the prior delta value from the prior master frame and offsets the path at the ITP time interval.

3.5.4 Robot Ring:

A “robot ring” is a group of robots that work cooperatively together, and are in close proximity to each other. These robots share data via RIPE; motion coordination is provided by Robot Link, system coordination via MASH. The robot ring definition may not include all of the robots in a workcell. The Robot Ring must include all the robots that will be using Robot Link, or using MASH to control robot program selection and execution. All ring robots need to be turned ON and correctly configured for these operations. A file called ROSIPCFG.XML is a user-supplied file that indicates the Robot Ring elements on each controller of the robot ring.

3.5.5 ROS IP CONFIGURATION FILE:

The data for inter-controller setup is in ROSIPCFG.XML. This file is loaded into “FRS:” memory on the controller. It indicates the “Robot Ring” for MASH control and also defines the “*i*Pendant Ring” to support *i*Pendant remote logon to a remote robot controller. There may be future functions added to this file. Since this file relies on IP and Name information of the robots, it must be created for each robot ring. Following is an example ROSIPCFG.XML.

```
<?xml version="1.0" ?>
<!-- The order implies the "index" in the ring -->
<ROSIPCFG>
  <ROBOTRING count="2" timeslot="100">
    <MEMBER name="RC21" ipadd="190.10.91.21"/>
    <MEMBER name="RC22" ipadd="190.10.91.22"/>
    <MEMBER name="RC23" ipadd="190.10.91.23"/>
    <MEMBER name="RC24" ipadd="190.10.91.24"/>
  </ROBOTRING>
  </ROSIPCFG>
```

All robots in the robot ring have a copy of this file installed on them.

3.6 OVERVIEW OF SYSTEM SETUP:

To use Robot Link, setup:

- Network Setup / HostComm Setup
- Setup Robot Link
- Master “Robot name definition” setup
- Link Pattern
- Master Setup
- Slave setup
- Slave master list
- Calibration data
- Testing Robot Link
- Optional EGD Setup (some I/O is required to signal the slave robot)

3.6.1 Hostcomm Setup

- You setup IP address and host name for each robot controller correctly, on TCP/IP setup screen. Otherwise unexpected robot may move by robot link synchronous motion.

And you should confirm that all robots share common setup about host name and IP address. for robot link network
For example, we assume that there are three robots, A, B, and C. If, at robot B, host name “RC21” is used for robot A but robot C set robot A's host name as “RC31”, then robot link does not work correctly. Also you need to take care for IP address.

- You should start FTP interface. Otherwise robot link synchronous motion does not work correctly. Please refer the following chapter of this manual.

- You should setup each item correctly on robot link calibration screen. You should calibrate relative location between master and slave robot accurately. This accuracy affects directly to the deviation of synchronous motion.

- You should setup the master robot link pattern and slave robot setup data correctly. Otherwise unexpected robot may move and target slave robot may not move at synchronous motion.

3.7 ABOUT TEACHING AND OPERATION

- At robot link program, you must avoid AXIS speed limit alarm. Synchronous motion is not guaranteed when axis speed limit alarm occurs.
For slave robot, joint angle speed to realize the synchronous motion for each axis is defined by not only master speed but also by position of the slave robot itself. It may be easy motion for master robot but it does not always so for slave robot according to the position. For example, if the synchronous motion forces slave robot to move around singularity point, slave robot may not follow master robot motion in specified speed. Please estimate robot link motion beforehand to avoid synchronous motion around singularity point for slave robot.

  Also, you should take care for too quick tool rotation of the master robot. Slave robots always try to follow master robot tool but cannot follow too quick tool rotation. In such a case, master robot tool rotational speed should be set slow enough. “SEC” speed unit for motion statement may be useful to control master robot tool rotational speed.

- Digital signal to show “Robot is master” and “Robot is slave” should be used to turn on safety signal light. This signal light should be mounted on robot, or another method should be prepared for safety.

- In robot link teaching, no one must in the motion envelope of slave robot. Especially if slave status signal is ON, the slave robot may move very fast to follow master robot motion.

- When you operate master robot in synchronous motion teaching, you must confirm that nobody is in motion envelope of slave robot.

- HOLD event or emergency stop in synchronization motion may change the offset distance between master and slave robot. Before re-starting synchronous motion from such a status, you should confirm current position of all robots. If necessary, you should do manual jog to move the robot to moderate position to re-start synchronous motion. According to the synchronous motion status, re-start at low override may be needed.

  You can specify low override automatically by external override selection functionality and PLC ladder program for the recovery of synchronous motion.

- With faster speed, the deviation of the synchronous motion between master and slave becomes larger. Please specify adequate motion speed to meet your requirement about the deviation.

3.8 ADDITIONAL INFORMATION

- If rail-mounted robot is used for robot link, you should take calibration position data as close as actual motion area used for application. This is to get accurate calibration data for actual application to minimize deviation of synchronous motion according to the position error from rail axis installation and absolute position error of the robot itself. For rail-mounted robot, please consider damper mechanism on robot hand beforehand to absorb the deviation.

- At slave robot controller, power failure recovery function cannot work if power is OFF when slave program is running. If slave program is already paused at the power OFF timing, the recovery function can work. In master program and normal program, this restriction is not applied.
  If needed, please include PAUSED output signal for program resume condition in your system.

- Robot motion statement in slave program should be linear motion.

- Position type of motion statement in slave program should be XYZWPR format.

- Incremental and offset statement is not available in slave program.

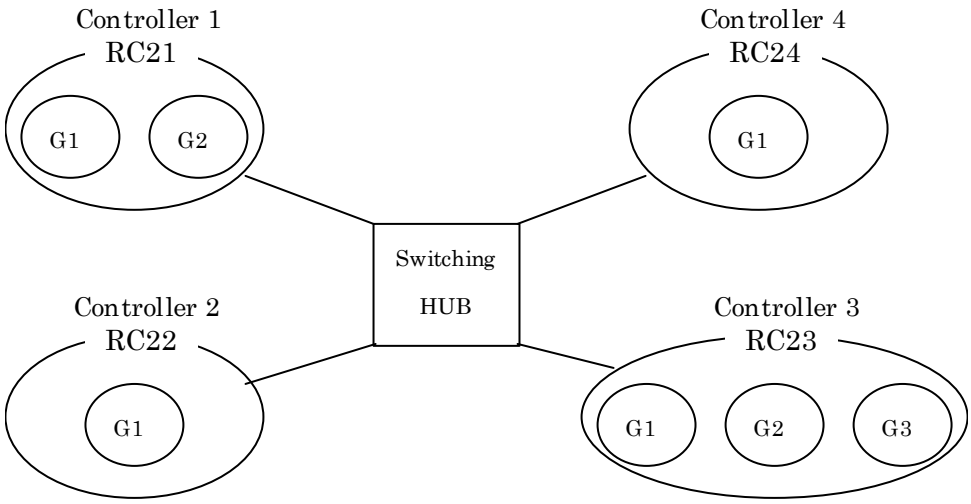
- Tool frame number should not be changed during synchronous motion.

- Fluent synchronous motion is available only when good communication status is kept among master and other slave robots. If communication to one slave robot is disturbed by noise on Ethernet, then all robots stop synchronous motion. In this case, all robots wait for recovery of the communication for certain time. Also, if one slave robot does not come to start point of the synchronous motion, then master and other slave robots wait for the delayed slave robot to reach the start point.

4 SETUP

To use Robot Link, set up Network configuration first, and then set up Robot Link configuration.

The following is sample system.



Controller 1 - Hostname is RC21, 2-motion group.
Controller 2 - Hostname is RC22, 1-motion group.
Controller 3 - Hostname is RC23, 3-motion group.
Controller 4 - Hostname is RC24, 2-motion group.

4.1 SETUP NETWORK

4.1.1 Set up TCP/IP

Display “TCP/IP Detailed Setup” screen according to 4-1-1 and set the following items.

- Robot name of oneself.
- Router name of router even if no router is exists.
- Board address of oneself (refer to above)
- Subnet mask
- Robot names and Internet addresses of all controllers to communicate by Robot Link function

⚠CAUTION
If space characters are included in parameters, R-J3*i*B controller cannot communicate via Ethernet properly.

The following is an example.

```
SETUP Host Comm
Robot name:                RC21
Port#2 IP addr:        190.10.81.21
Subnet mask:               255.255.0.0
Board address:             08:00:19:02:F3:50
Router IP addr:        190.10.255.0

Host Name (LOCAL)          Internet Address
1          RC21            190.10.91.21
2          RC22            190.10.91.22
3          RC23            190.10.91.23
4          RC24            190.10.91.24
5
```

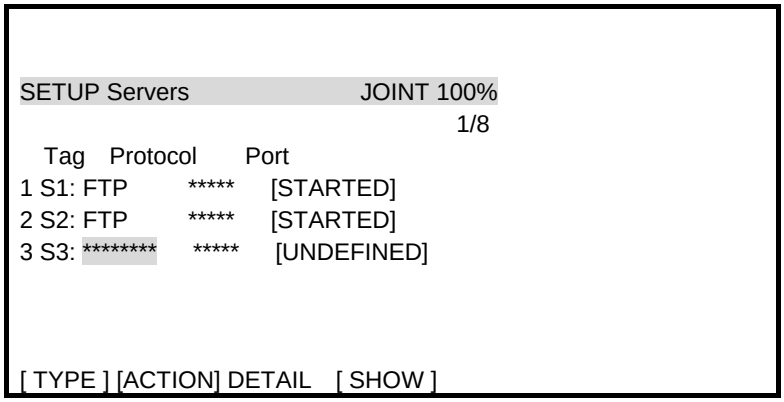
- Node name and Internet Address should be unique for each controller.
- Set same Host Name and Internet Address table to all controllers that communicate via Robot Link function but own “Node name” and “Board address” should be unique.

4.1.2 Set up and starting FTP

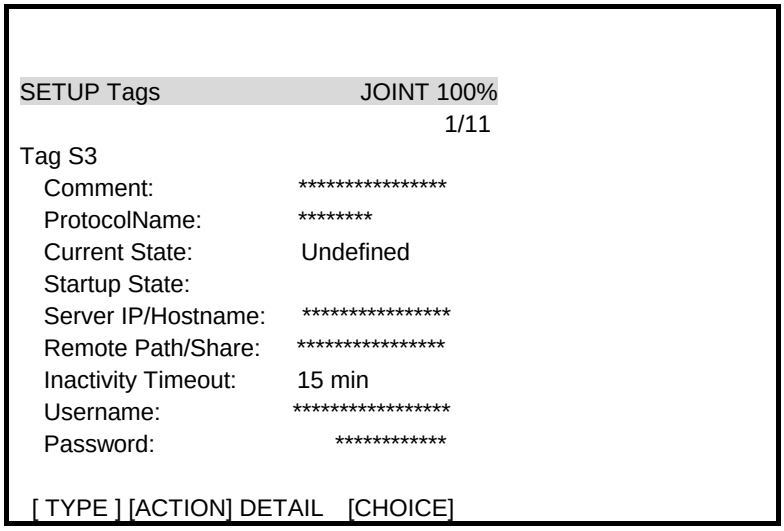
1. Press MENUS
2. Select SETUP
3. Press F1, “TYPE”
4. Select Host Comm

```
SETUP Protocols                JOINT 100%
                                       1/ 3

    Protocol    Description
1   TCP/IP        TCP/IP Detailed Setup
2   FTP           File Transfer Protocol




[ TYPE ]         DETAIL      [ SHOW ]
```

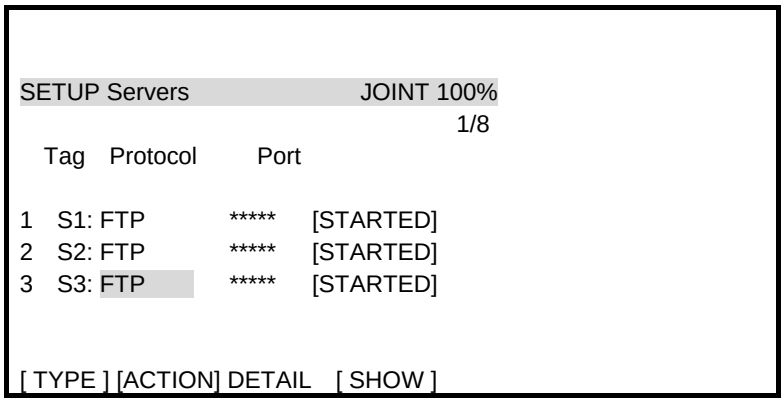
5. Press F4, “SHOW”
6. Select 3, Servers



7. Move the cursor to the server tag you want to set up and press F3, “DETAIL”.



8. Move the cursor to “Protocol Name” and press F4, “CHOICE”.
9. Select FTP and press ENTER.
10. Move the cursor to “Startup State” and press F4, “CHOICE”
11. Select START and press ENTER.
12. Turn off and on the power supply switch.
13. After the system comes up, check if current status is “STARTED” on the following screen.



Note: If current status is not “STARTED”, TCP/IP setup may be incorrect.

4.1.3 Set up Full Duplex mode on R-30*i*A Controller

Set system variable $ENETMODE.$FULL_DUPLEX = TRUE

4.1.4 Set up Full Duplex mode on switching hub

If switching hub has Full/Half duplex switch, set it to “Full Duplex”.

4.2 CHECKING NETWORK CONFIGURATION

After setting up the network, check the following points.

1. Is Ethernet cable connected between the controller and switching hub properly?
   If not, connect cable.
2. Is orange LED near 10/100Base-T jack on main CPU printed board lighting?
   If not, disconnect the Ethernet cable and connect again then turn off and on the power supply switch of the controller and switching hub.
   If the LED is still not lighting, main CPU printed board may have some troubles.
3. Is status of S1 tag on SETUP Servers screen “Start”?
   If not, check TCP/IP setup again.

4.3 SETTING UP ROBOT LINK

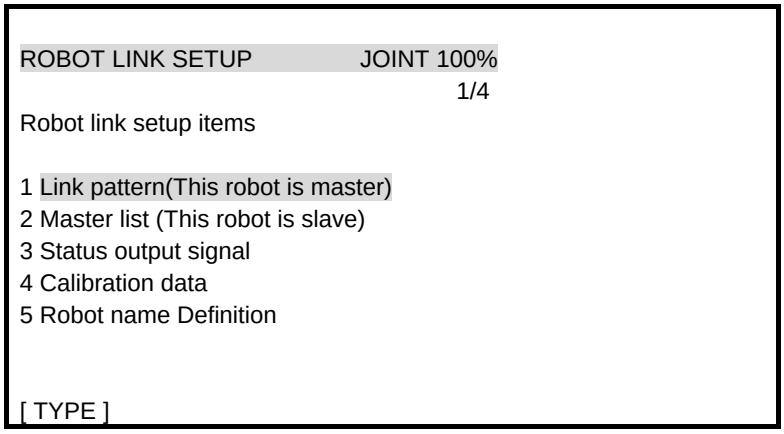
Master robot has “Link pattern” information. Slave robots have information about master robot to follow.

In this manual, we assume the following situation.

- There are robot controllers RC21 (G1, G2), RC22 (G1), RC23 (G1, G2, G3), RC24 (G1).
- Master robot: RC21(G1)
- Slave robot: RC22 (G1), RC23 (G1), RC24 (G1)

At first, move to Robot link setup screen as follows.

1. Press MENUS
2. Press F1, “TYPE”
3. Select “Robot Link” and press ENTER



Note that if any setup parameter is changed, please cycle power.

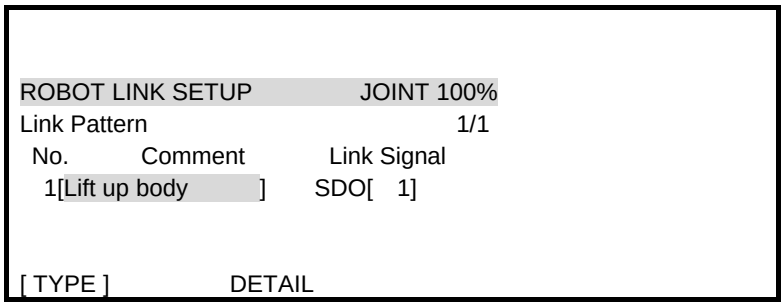
4.3.1 Set up Link pattern (Master Robot)

Link pattern is robot group setup to perform synchronous motion.
For example, the following link patterns are available to define.

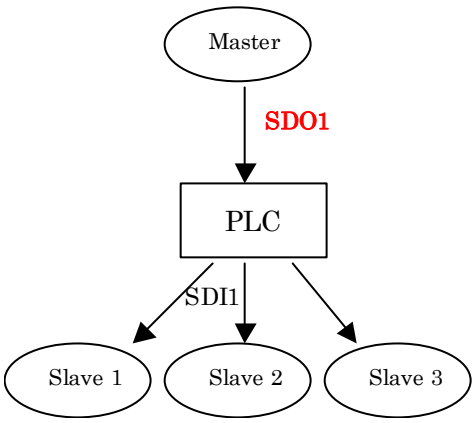
Link pattern	Master	Slave	Slave	Slave
Current example	RC21(G1)	RC22(G1)	RC23(G1)	RC24(G1)
Example #2	RC21(G1)	Not use for link	RC23(G1)	RC24(G1)
Example #3	RC22(G1)	RC21(G1)	RC23(G1)	RC24(G1)

⚠CAUTION
- Only 1 group can be a slave robot on a controller.
- NOBOT, Positioner or such additional group cannot be a slave robot.
- NOBOT cannot be a master robot.
- Integrated extend axis robot cannot be either master or slave robot.

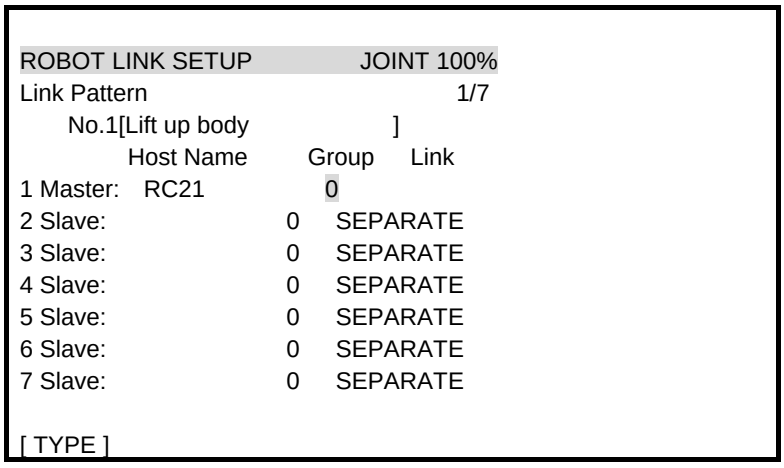
1. At RC21 robot controller, in robot link setup screen, select “1. Link pattern (This robot is master)”And press ENTER.



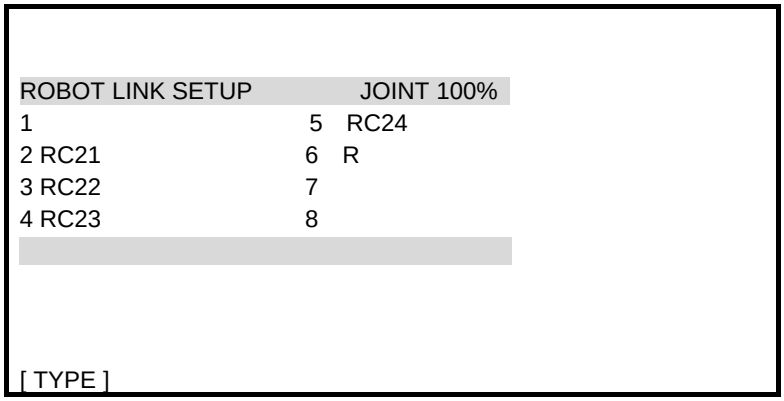
2. Comment for Link Pattern can be set.
3. Set link signal.
   This output signal is from master robot to slave robots. Master uses this signal to notify the completion of the synchronous motion to slave robots.



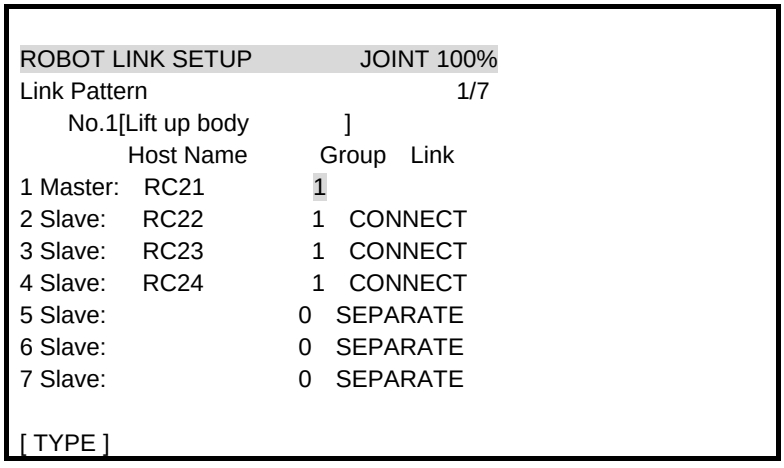
4. Press F3, “DETAIL”



5. Move cursor on host name and press F4, “CHOICE”.



6. Select host name and press ENTER.
7. Move cursor on item “Link” of slave robots then press F4, “CONNECT”.“SEPARATE” is used if the slave robot has troubles.

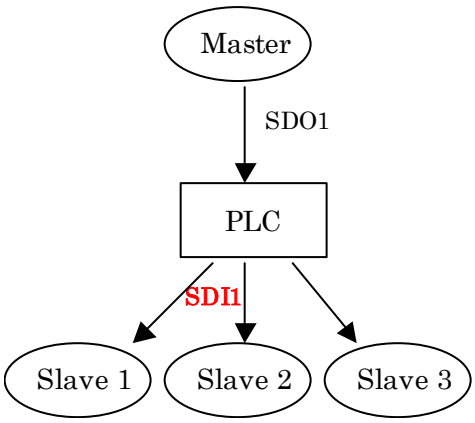


4.3.2 Set up master robot information (Slave Robot)

1. Select “2. Master list (This robot is slave)” and press ENTER.

```
ROBOT LINK SETUP                JOINT 100%
Master List                              1/1
No. Host Name   Group    Link signal
  1             0          SDI[   1]


[ TYPE ]                  [CHOICE]
```

2. Press F4, “CHOICE”.
3. Select host name of master robot and press ENTER.
4. Set motion group number of master robot.
5. Set link signal. This signal is from master robot to notify completion of synchronous motion.



4.3.3 Setup Status Signal

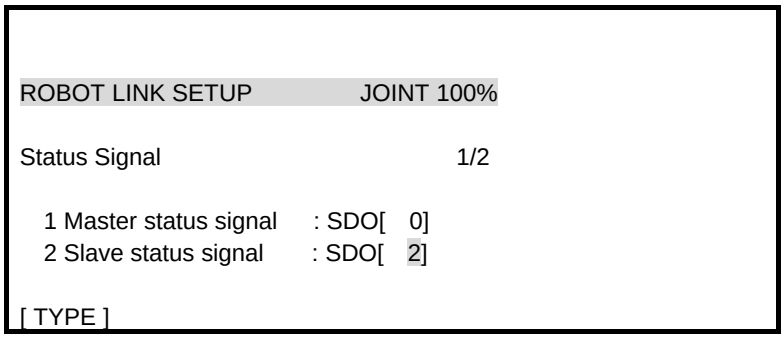
Set up Status Signal on both master and slave robot.

1. Select “3 Status output signal” and press ENTER.
   Screen will be different according to its motion group count.
2. Set “Master status signal” if the robot is a master robot.
3. Set “Slave status signal” if the robot is a slave robot.

Example 1: RC21 controller (Master), which has 2-motion group.

```
ROBOT LINK SETUP                JOINT 100%

Status Signal                            1/4

  1 Master status signal(G:1): SDO[   2]
  2                    (G:2): SDO[   0]
  3 Slave status signal (G:1): SDO[   0]
  4                    (G:2): SDO[   0]

[ TYPE ]
```

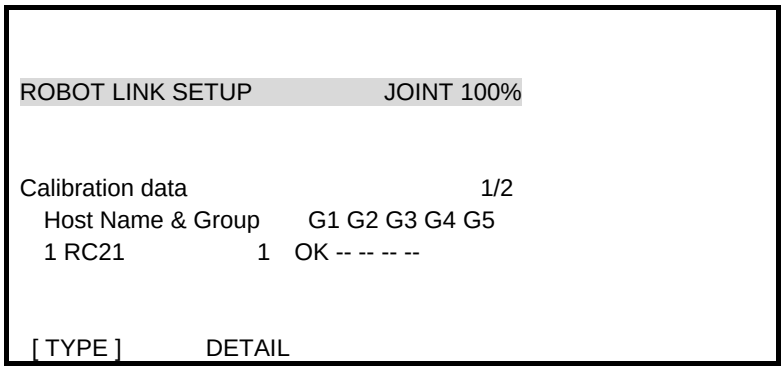
Example 2: RC22 controller (Slave), which has 1-motion group.



4.3.4 Set up Calibration Data (Slave Robot)

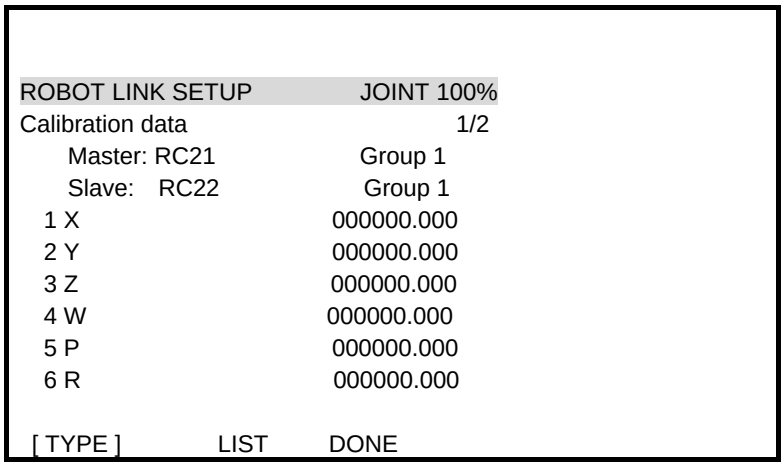
This section describes how to input Calibration Data. Refer to section 5 how to get Calibration Data.

1. At slave robot, select "4. Calibration data" and press ENTER.



This screen shows whether calibration is done for each master robot. "OK" means that calibration is done, and "—" shows that calibration is not done. "G1 G2 G3 G4 G5" shows motion group of master robot. If the master robot has only one motion group, "G1 G2 G3 G4 G5" does not appear.

2. Move cursor to select motion group of master robot and press F3, "DETAIL".



3. Input calibration data to 1 (X) to 6 (R). Refer to section "5. Calibration" how to get calibration data.
4. Press F4, "DONE" when all values were set.
5. Once calibration was done, F4 label changes to "CHANGE". Move cursor and press F4, "CHANGE" to modify value.

6. Press F3, “LIST” to return previous screen. If calibration was done, “OK” appears at the motion group.

4.3.5 Set up Communication Rate

Set communication rate value to system variable $RK_MOTNRATE[1] at both master and slave robot. Default value is 6. The time lag of motion between master and slave robot is 8 msec per communication rate. Lower limit of communication rate is based on count of slave robots. Refer to the following table.

Count of Slave robots	1	2	3	4	5	6
Lower limit of Communication Rate	3	4	4	6	6	6

Notes) Normally, deviation between master and slave robot in synchronous motion is
(motion speed (mm/sec) x $RK_MOTNRATE[1] / 125) mm.

4.3.6 Set up acceleration time during synchronous motion

Acceleration time of both master and slave robots are equal and fixed during synchronous motion. So acceleration time should be calculated and set according to max motion speed during synchronous motion beforehand.

System variables for acceleration time are $RK_GROUP[J].$accel_time1 and $RK_GROUP[j].$accel_time2. (J is motion group number for synchronous motion).

Default acceleration time values are set for S-430iR/165kg type robot to be able to do 1000mm/sec linear motion. Usually, not so high-speed motion is required during synchronous motion so default vales may be useful.

However, if fine-tuning of acceleration time is required because robot does vibrate motion, calculate them according to the following expressions.

GP=Object robot group
Vp-max＝ Maximum speed during synchronous motion.
i ＝ Vp-max／100
Vr ＝ Vp-max – i×100
A 1= $CF_PARAMGP[GP].$acctime_tb1[i]
B 1= $CF_PARAMGP[GP].$acctime_tb1[i+1]
A 2= $CF_PARAMGP[GP].$acctime_tb2[i]
B 2= $CF_PARAMGP[GP].$acctime_tb2[i+1]
If i = 0 then A1=A2=0

Payload = Ordinary payload.
Payload-max = Maximum permissible payload

ACC1 = A1 + (B1 – A1) ×Vr/100
ACC2 = A2 + (B2 – A2) ×Vr/100
ACC = ACC1 + (ACC2 – ACC1)×Payload/Payload-max

$RK_GROUP[J].$accel_time1 = ACC×2/3
$RK_GROUP[J].$accel_time1 = ACC×1/3

(J is motion group number for synchronous motion).

5 CALIBRATION

In order to perform master /slave motion, each slave/master pair in your system must be calibrated. Calibration is the positional relationship of the slave robot origin to each of its master robots' origins.

Overview the calibration procedure:

1. Select a LINK PATTERN on a master robot.
2. Determine the master/ slave pairs that need to be calibrated

For each master/slave pair:

3. Create a calibration data program on the master and slave robots

At three places in the area where the work envelopes of the two robots overlap:

   a. Jog the robots to a unique point where master and slave robot's TCPs touch
   b. Record that position in the calibration program for each robot.

4. Copy the TP programs to PC from each robot controller.
5. Calculate the calibration data using Robot Link Calibration Tool installed on PC.
6. Set the output data calculated on PC to the slave robot's controller.
7. Repeat Step 3 to Step 6 as many times as the number of slave robots in the LINK PATTERN selecting the next slave robot from the pattern each time.

5.1 SETTING THE TCP FOR CALIBRATION

You can find out the relative position between the master robot and a slave robot checking the positions of any three points included in the cross section of the two robots workspaces in each robot's world frame. We call the three points that are used to find out the relative position between two robots as 'reference point'.

Calibration consists of two-step works. First, contact master's TCP and slave's TCP and record the position. You have to this work three times for different contact points, namely you have to record three reference points as a TP program on each robot controller. Second, process the TP programs on PC and get the relative position between master and slave.
The calibration accuracy is depends on how to select reference point. So please take care following items.

1. Please avoid the position near the limit of workspace or singular points because absolute position accuracy is relatively low.
2. When the distance of any two-reference points are short or when three reference points are in a line, calculation error will be increase. For example, take three vertex of triangle of edge length about 1m such that each point. Can be reached easily from both master and slave robots.

Calibration TCP is used to record the reference points. Usually, you may need to fix some tool for calibration like a needle that can easily record reference points. And set the TCP on the tip of the needle. The tool for calibration should be easily point reference point and should not bend depending on the robot's pose. For easy example, like a needle can be used. Since too sharp tip is dangerous, make round the tip and be careful to treat the needle.
If you can set the reference point without such a calibration tool, it is not always necessary to prepare calibration tool. As a substitute, you can use mechanical frame or the pre-attached hand's TCP and etc.

You can set TCP in the common TCP setup screen with 3 points method or direct method. The accuracy of TCP affects the accuracy of calibration. So you should set TCP as precise as possible checking the accuracy with WPR jogging.

5.2 RECORDING REFERENCE POINTS

1. Please select the calibration TCP as current TCP.
2. Contact the master robot's TCP and slave robot's one, record the current position in a TP program on each robot controller. Then the position index must be consistent between master's TP program and slave's TP program. Therefore, the master program's P [1] and the slave program's P [1] must be the same reference point. Position data type must be Cartesian. If joint data type is selected, you can't read position data on PC later.
3. Please repeat Step 2 two times in other point. As a result, you have to record three different points.

【How to select reference points】
The reference points are used to calculate the relative position between master robot and slave robot. If a reference point is near the limit of workspace or near the singular point or if the distance of any two of the three points is short comparing with other two edges or if all three points are in a line, the accuracy of calibration becomes low. For example, take three vertex of triangle of edge length about 1m such that each point can be reached easily from both master and slave robots.

5.3 CALCULATION OF CALIBRATION DATA

1. Please set as $FILECOMP.$TPP=TRUE on system variable screen.
2. Please transport the TP programs that are recorded three reference points to PC via Memory card or MS-DOS formatted floppy disc.
3. Please set back as $FILECOMP.$TPP=FALSE on system variable screen.
4. Start the robot link calibration tool on PC. Then you can see the screen as Fig. 5.3.
5. Specify the directory containing the TP programs with Directory: list box and Drive: box.
6. Slave Robot: TP Program: The program made with slave is selected from among the list box, and TP Program of Master Robot: select the master program corresponding to the program from among the list box.
7. Set the motion group of slave robot in Slave Robot.
8. Set the motion group of the master robot in Master:
9. Select Direct about Teach Type of Slave Robot and Master Robot.
10. Please click the Calibrate button.
11. The value is displayed to X Y Z W P R and Mean Err. Max Err. Please refer to 5.5 troubleshooting when nothing is displayed.
12. The value of Mean Err, Max Err is a value that becomes the standard of the accuracy of calibration. Mean Err generally becomes about 2mm though this value changes depending on the posture of the robot at how to get the reference point and that. Especially, please refer to 5.5 troubleshooting because there is a possibility that the procedure is wrong when A exceeds 10mm.
13. Please set X, Y, Z, W, P, R in slave robot and set setting with master setup of the robot link STUP screen on the robot controller.

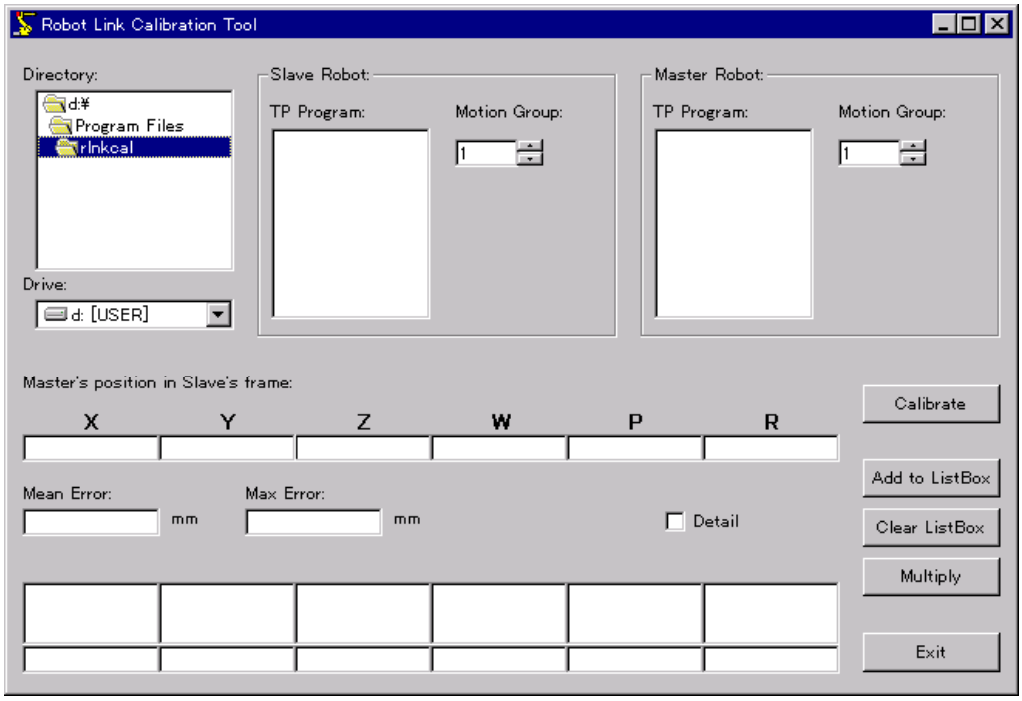


Fig. 5.3 Screen of Robot Link Calibration Tool when

5.4 INDIRECT CALIBRATION

The calibration method where is explained from section 5.1 by section 5.3 is required to be set up in the position by which the master and slave robot can share three reference points. In a word, it is demanded that the distance between both robots is near and it not be between both robots the obstacle (case like Fig. 5.4(a)). However, when the point cannot be shared (case like Fig. 5.4(b)) because slave is away from master. The above-mentioned method cannot be executed. This chapter explains the calibration method for this case.

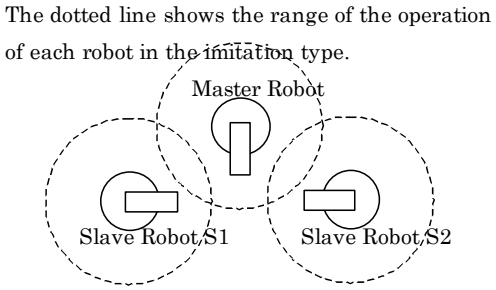


Fig. 5.4(a) Calibration is directly possible

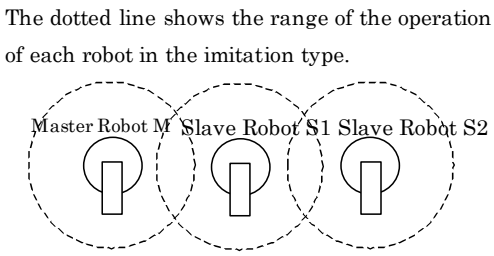


Fig. 5.4(b) Calibration is directly impossible

5.4.1 Idea of indirect calibration

Please look at Fig. 5.4(b). Though S1 can do calibration directly because the distance with M is near. Because the distance with M is away, S2 cannot do calibration directly. However, S2 and S1 are assumed that the distance of both is near. "Near" is to mean three reference points can be shared and near extent to be able to do calibration directly and there is not an obstacle either here.
The idea of indirect calibration is explained. First of all, S1 can learn the position of M because S1 can do calibration directly. In addition, if S1 is set as a temporary master, and the calibration is done with S2, S2 understands the position of S1 seen from S2 because S2 is near the distance of S1. Therefore, S2 can learn the position of M thought that information of both will be matched from S2 by S1's passing. The idea of indirect calibration is brought together as follows.

- The calibration is done directly between M (master) and S1 (Slave). The position of M seen from S1 is obtained.
- The calibration is done directly between S1 (temporary master) and S2 (slave). The position of S1 seen from S2 is obtained.
- The position of M seen from S2 is obtained by using the result of 1 and 2. In a word, the calibration result between M and S2 is indirectly obtained.

The above-mentioned explanation was indirect calibration (indirect one) that passed slave only by one. This idea can be expanded and be indirect calibration (indirect n) which passes n slave in general. However, the error accumulates increasing of the number of the robot that passes, too. Please think up to two indirectly practicably.

5.4.2 Method of indirect calibration

5.4.2.1 Calibration method one indirectly

It is assumed that the following conditions consist as shown in Fig. 5.4(b).

【Condition 1】 When S1(Slave) is M(Master) and can do calibration directly.

【Condition 2】 When S2(Slave) is M(Master) and can do not calibration directly. However, S2 (slave) can do calibration directly with S1 (temporary master) when thinking S1 to be a temporary master.

The procedure by which the position of M (master) seen from S2 (slave) is indirectly obtained is explained.

1. Please do calibration directly by thinking S1 to be a temporary master between S1 (temporary master) and S2 (slave) according to the procedure of Section 5.1 to 5.3. Please go up to Section 5.3 Step 12. The work set to the controller of Section 5.3 Step 13 is unnecessary.
2. The calibration result of S1 (temporary master) and S2 (slave) to be displayed respectively of X, Y, Z, W, P, R, Mean Err and Max Err of the screen in Fig. 5.3(a). Please click the Add to List Box button. Then, The value of X, Y, Z, W, P, R is copied onto the list box under the screen respectively. A special tool is used as it is without ending with the following Step 3.
3. Please do calibration directly between M (master) and S1 (slave) according to the procedure of Section 5.1 to 5.3. Please go up to 5-3 Step 12.
4. The calibration result of M (master) and S1 (slave) to be displayed respectively of X, Y, Z, W, P, R, Mean Err and Max Err of the screen in Fig. 5.3(a). In addition, the calibration result of S1 (temporary master) set with Step 2 and S2 (slave) is displayed in the list box under the screen. Please click the Add to List Box button. Then, the value of X, Y, Z, W, P, R is copied onto the second line of the list box under the screen respectively. The data of the first line remains as it is.
5. Calibration data between S1 (temporary master) and S2 (slave) is displayed in the first line and calibration data between M (master) and S1 (slave) is displayed in the second line in the list box under the screen. Please click the Multiply button. The value is displayed in the text box under the list box. It is one indirectly result to which this value is synthesized, in a word, the calibration result.
6. Please set X, Y, Z, W, P, R in S2 (slave). This setup is done with MASTER SETUP of the robot link screen of SETUP on the controller of S2.

【Reference】

The content of the list box can be deleted by clicking the Clear List Box button when a value wrong in the list box under the screen is set.

5.4.2.2 Method of n indirect Calibration

We assumed that the following condition is satisfied.

【Condition 1】 The calibration between M (Master) and S1 (Slave) can be performed.

【Condition 2】 The calibration between M (Master) and S2 (Slave) cannot be performed directly.
However, the calibration between S1 (temporary master) and S2 (Slave) can be performed if we treat S1 as a master.

: :

【Condition n+1】 The calibration between M (Master) and S (n+1) (Slave) can not be performed.
However, the calibration between S(n) (temporary Master) and S (n+1) (Slave) can be performed if we treat S(n) as a master.

The following procedure explains how to perform the calibration between M (master) and S (n+1) (slave) by indirect method.

1. Set the following data in the list box under the screen of a special tool of the personal computer (Fig. 5.3(a)) according to the same procedure as Section 5.4.2.1.
   Line1: Calibration data between S(n) (temporary master) and S(n+1) (slave)
   Line 2: Calibration data between S1 (temporary master) and S2 (slave)
   : :
   Line n+1: Calibration data between M (master) and S1 (slave)
2. Click the Multiply button. The indirect calibration data is computed and displayed in the text box under the list box.
3. Set the calibration data (X, Y, Z, W, P, R) into S (n+1) (slave) robot at the following screen.
   SETUP > Robot Link > MASTER SETUP

[Maximum number of robots for the indirect calibration]
The each calibration error of each line in the list box would be accumulated and affect the total performance of the indirect calibration. To get better calibration performance, n should be up to 2.

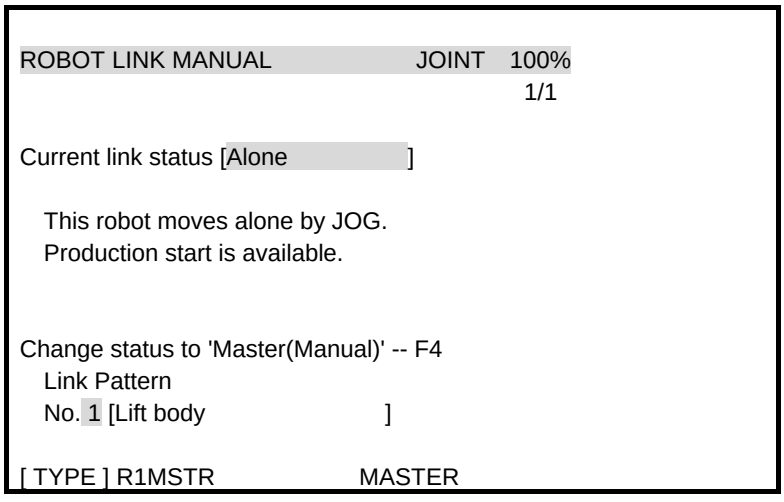
5.5 TROUBLESHOOTING

1. Even if the Calibrate button is pushed, the calculation result is not displayed.
   Please confirm the following items.
   - After the value of $FILECOMP.$TPP had been made TRUE, was the program saved?
   - Is the position data of the program XYZWPR form?
2. Mean Err exceeds 10mm.
   Please confirm the following items.
   - Is TCP correct? Please confirm TCP being selected now is TCP for calibration (both the slave and the master), do posture jog if it is correct, and confirm set accuracy of TCP. When TCP is corrected, it is necessary to do teaching the reference point over again.
   - Is the index number of the position data of three reference points the same as master in slave?
   - Please confirm the program taught with both master and slave is executed in the step, and TCP each other is corresponding.

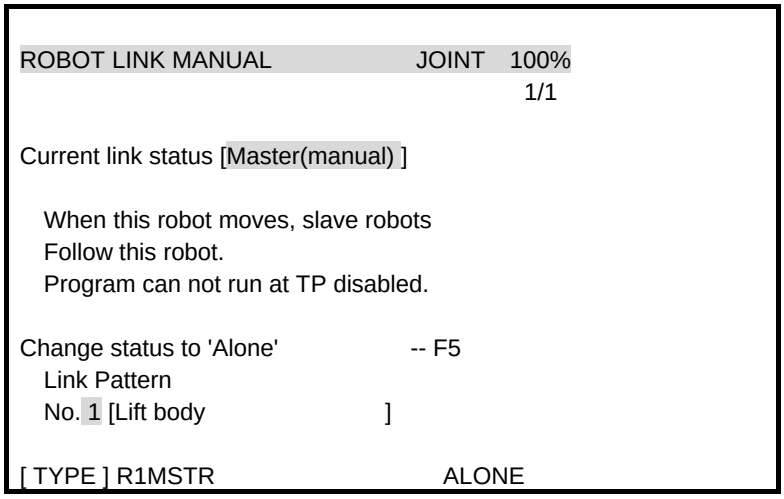
6 VERIFICATION OF COMMUNICATION AND SYNCHRONOUS MOTION

6.1 THE FOLLOWING IS A PROCEDURE TO VERIFY COMMUNICATION AND SYNCHRONOUS MOTION. AFTER ALL SETUP ITEMS (EQUIPMENT, WIRING, AND CONNECTION) ARE FINISHED, THE USER SHOULD VERIFY COMMUNICATION AND SYNCHRONOUS MOTION BY THE FOLLOWING OPERATIONS:

1. Turn on the power to the HUB and then turn on all robot controllers.
2. Set the slave robot(s) to remote state.
   The conditions for remote state are as follows.
   - Disable Teach pendant
   - Set remote switch to REMOTE
   - Disable single step mode
   - Reset all alarms
   - Reset HOLD input
3. Select “Robot Link” manual function screen on the teach pendant of the master robot according to the following operation:



4. Enable the teach pendant and press [F4 MASTER].
5. Confirm that current link status is MASTER, which means that the connection for synchronization is established through the ethernet local network. Confirm that the BUSY LED is ON for each slave robot(s) in the link pattern.
   The following screen is displayed on the master robot.



If the current link status is “Link incomplete”, press [F4, MASTER] again.

6. Change jog frame on the master robot to WORLD, JOG, or USER and lower the override (initially it should be about 5% until you are familiar with jogging multiple robots.) Jog the robot in each direction X, Y, or Z to confirm that all robots in the link pattern move synchronously.
7. After synchronous motion is verified, press [F5 ALONE] on the master robot. Stopping synchronous jog mode on the master causes an error to occur on each slave robot, and each slave robot display indicates that it is in “ALONE” mode. Reset each slave robot.
8. The E-STOP signals of all the robots in a linked cell are typically all serially connected. If E-STOP is pressed on the master robot, all robots will post an error. The master robot will indicate “Link Incomplete” and the slave robots indicate “ALONE” mode. Clear the E-STOP alarm and reset each robot in the link pattern then press MASTER on the master robot to resume synchronous jogging with the slave robot(s.)
9. When HOLD is pressed on the slave robot, the BUSY LED on the slave robot teach pendant is turned OFF and an alarm is posted on the master robot. The slave robot indicates it is in “ALONE” mode and the master indicates “Link Incomplete.” Clear the alarm on the master robot then press MASTER on the master robot to resume synchronous jogging with the slave robot(s.) Pressing HOLD on the master robot does not change the MASTER (MANUAL) mode on the master and there is no mode change to any slave robot in the link pattern.

NOTE
All robots in the link pattern move synchronously when the master robot is jogged in this status.

6.2 IF VERIFICATION FAILS, SETUP ITEM REVIEW

The following outlines the areas of communication setup and other Robot Link setup that should be revisited when the master robot does not enter MASTER (MANUAL) mode for master / slave jogging.

When [F4, MASTER] is pressed, an alarm may occur regardless of the setting for master/slave.
The alarm indicates that either the master or one or more of the slave robots in the link pattern are not ready to jog in synchronous mode. Verify and correct the following items (refer to the chapter “Setup”):

On the master robot check:
- If an unrelated alarm is posted on the master robot
- Protocol setup for host communication
- Server setup for host communication

- Link pattern setup for robot link

On each slave robot: check:
- If an unrelated alarm is posted
- Protocol setup for host communication
- Server setup for host communication
- Master setup for robot link
- Calibration to master robot is done

6.3 PROCEDURE TO VERIFY THE LINK STATUS WHEN THE MASTER SHOWS "LINK INCOMPLETE."

```
ROBOT LINK MANUAL                    JOINT   100%
                                                1/1

Current link status [Link incomplete ]

   This robot can not move, because slave
   Robots are not ready.

Change status to 'Master(Manual)'-- F4
Change status to 'Alone'              -- F5
   Link Pattern
   No. 1 [Lift body                   ]

[ TYPE ]R1MSTR            STATUS    MASTER    ALONE
```

When the link status is "Link incomplete", as shown above, the master robot cannot be moved by any operation. Perform the following steps to verify communication and synchronous motion:

1. Change the link status of the master robot to ALONE and press the HOLD key on the slave robot in order to turn off its BUSY LED on the teach pendant. After that, reset the HOLD input and any other alarms.
2. Turn off and on the power of HUB, then verify communication and synchronous motion by the procedure in section 6-1 (above.)
3. If the link status does not change to Master (Manual) using the above operations, press [F3 STATUS] to display the following screen on teach pendant.

```
ROBOT LINK STATUS                    JOINT   100%

Current Link Pattern
     No. 1 [ Lift Body                  ]
          Robot          Status          Sync.ID
Master:  RC21    G1:Link incomplete      0
Slave:   RC22    G1:Slave(Manual)         0
Slave:   RC23    G1:No response            ***
Slave:   RC24    G1:Slave(Manual)         0
Slave:           G0:                     ***
Slave:           G0:                     ***
Slave:           G0:                     ***

[ TYPE ]              DETAIL
```

Perform diagnostic measures on any slave robot whose status is “No response”. Disable the teach pendant of the master robot to avoid a DEADMAN alarm (Note that an alarm on the master robot may cause alarm(s) on the slave robot(s).) Verify the following items (for detail on the method to verify, refer the chapter “Setup”:)

Verify setup items on the master robot:

- Confirm the host name setup in the HOST COMM setup page under TCP/IP DETAIL. Check that the IP address for the slave robot is correct.

Verify setup items on the slave robot whose Link Status is “No response:”

- Confirm the Host Comm setup includes the host name of the master robot and that the master robot IP address is correct.
- Confirm that the FTP servers’ state is STARTED in host communication server setup screen.
- Confirm the “Master List” setup includes the master robot name and a link signal in the robot link “master list” setup screen.
- Confirm the calibration data is entered in the “calibration data” setup detail screen, and that “OK” appears in the previous setup screen.

After correcting any invalid setup, turn off and turn on the power of the robot controller. Perform the operations described in Section 6.1 to verify communication and synchronous motion.

6.4 IF VERIFICATION FAILS, COMMUNICATION HARDWARE REVIEW

If the link status of the master still displays “Link Incomplete”, press [F3 STATUS] to verify determine if a slave robot has “No response” status. After disabling the Teach pendant of the master robot, verify the following items:

Verify the ethernet connections on the “No response” slave robot:

- Confirm whether the orange LED in the plug for Ethernet cable on the MAIN CPU board is turned on.

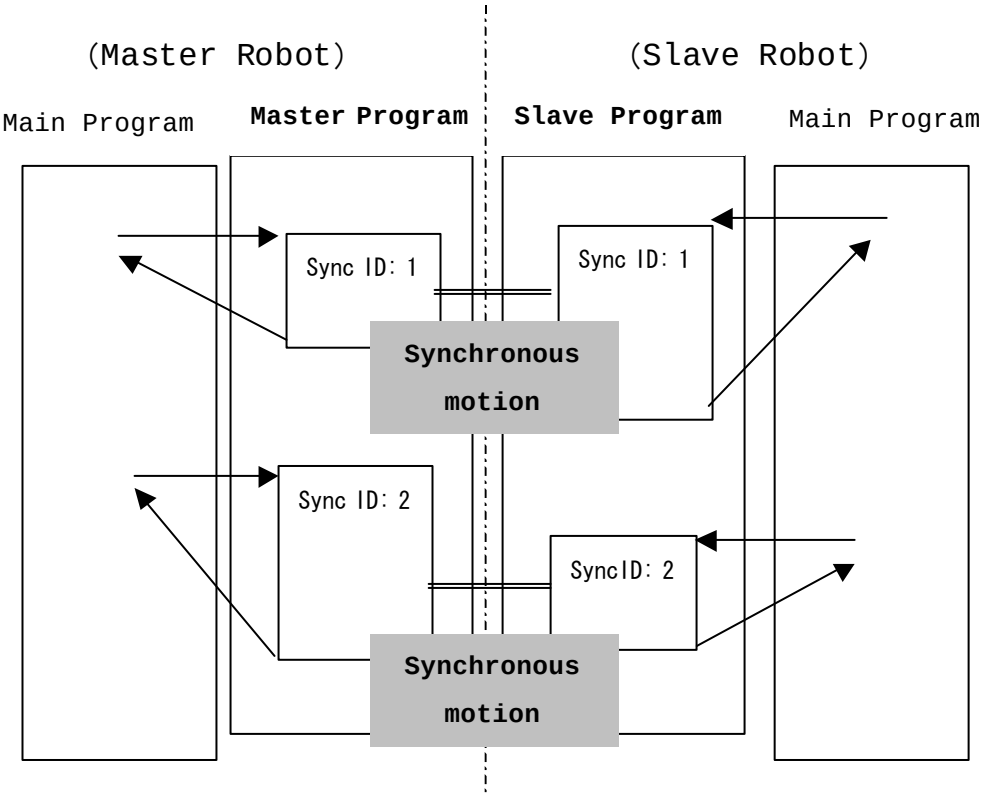
  If that LED is not turned on, even if the power of both HUB and the robot controller is turned on, it is possible that the MAIN CPU board has some defects. Please change the MAIN CPU board in this case.
- Confirm whether both green LEDs in the plug for Ethernet cable on MAIN CPU board are turned on and off.

  A. If both green LEDs are turned on and off correctly, it is possible that the connection between Ethernet cable and the HUB is wrong. Please insert the ethernet cable into another port in the HUB or install a different ethernet cable. Verify by pinging other robots hooked to the HUB to see if basic communication is working.
  B. If only one LED of the green LEDS is turning on and off, review the system variables $RK_SYSCFG.$LPARAM[1] and $RK_SYSCFG.$LPARAM[2]. $LPARAM [2] should be counting up; this is the correct mode for this parameter. If $LPARAM [1] is counting up too, it is possible that MAIN CPU board has some defects. Please change MAIN CPU board in this case. If $LPARAM [1] is not counting up, confirm the setup parameters again.

After these verifications, turn off and on the power of the robot controller. Do the operation described in Section 6.1 to verify communication and synchronous motion.

7 PROGRAMMING

Synchronous motion is programmed in special TP programs. The sub-type for master robot synchronous motion is “master” and the program is called the “Master Program.” The program sub-type for synchronous motion of a slave robot is set to “slave” and the program is called a “Slave Program.” The structure for executing synchronous motion programs is as follows.

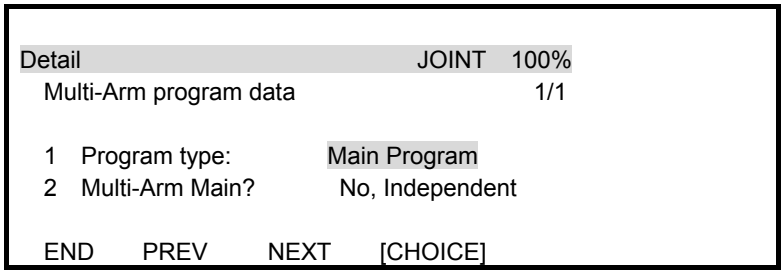


7.1 PROGRAMMING FOR MASTER PROGRAM

1. Display program detail screen
   Creating new program
   Press [SELECT] key, and press [F2] (CREATE) key.
   Enter program name, and press [F3] (DETAIL) key. > Step 2
   Setting the program taught already to the master program.
   Press [SELECT] key, set cursor to that program.
   Press [F->]（>） key, and press [F2]（DETAIL） key.

   Set motion group for the master program to the same group as the main program.

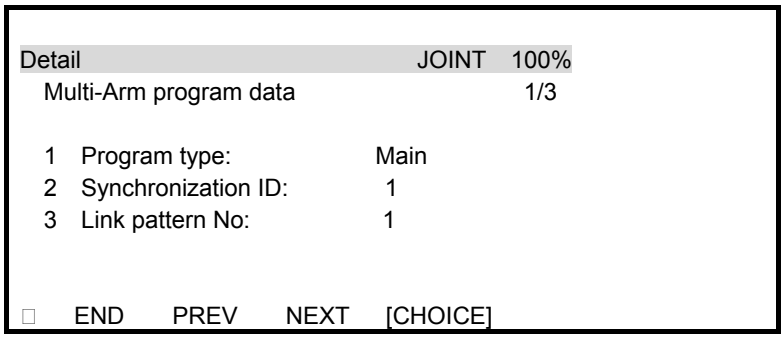
2. Press [F3] (NEXT) key again and again until Robot link program data screen is displayed. Note that this screen is not displayed, when the program is paused or executed.



Main Program
R.link Master Sub prog
R.link Slave Sub prog
Slave Alone

No, Independent
Yes, Head of Family
Yes, Family member

3. Press [F4] ([CHOICE]) in above screen, and select R link Master Sub in sub menu.



4. Set each item.

Item	Contents	Range
Synchronization ID	Set ID for slave program that pairs this master program. If the pairing slave program is not created set temporary value. The synchronous ID is used in order to avoid that the unexpected programs synchronize with this master program in case that there are some synchronous motions.	1-99999
Link Pattern No.	Set link pattern number. Set the number for the used link pattern beforehand.	$RK_SETUP. $NUM_PTN Don't change these system variables.

5. Press [F1] (END) to return the program edit screen.
6. Teach the motion for the master robot. The teaching method is same as usual teaching method.

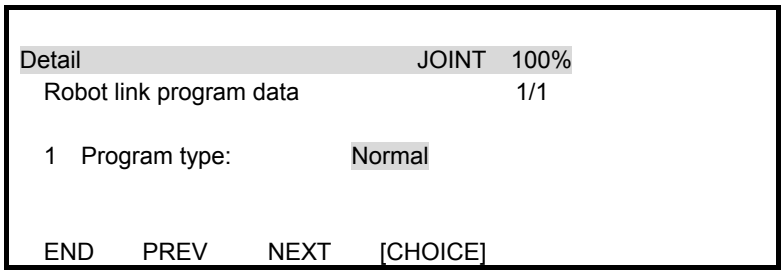
7.2 PROGRAMMING FOR SLAVE PROGRAM

1. Display program detail screen
   Creating new program

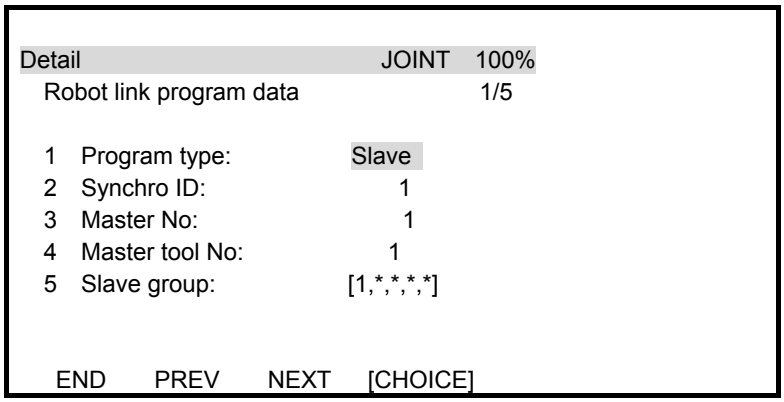
Press [SELECT] key, and press [F2] (CREATE) key.
Enter program name, and press [F3] (DETAIL) key. > Step 2
Setting the program taught already to the master program.
Press [SELECT] key, set cursor to that program.
Press [F->] (>) key, and press [F2] (DETAIL) key.

Set motion group for the slave program to the same group as the main program.

2. Press [F3] (NEXT) key again and again until Robot link program data screen is displayed. Note that this screen is not displayed, when the program is paused or executed.



3. Press [F4] ([CHOICE]) in above screen, and select SLAVE in sub menu.



4. Set each item.

Item	Contents	Range
Synchronization ID	Set ID for slave program that pairs this master program. If the pairing slave program is not created set temporary value. The synchronous ID is used in order to avoid that the unexpected programs synchronize with this master program in case that there are some synchronous motions.	1 - 99999
Slave Group	Set the motion group for synchronous motion. Set cursor to this item and press [F4] (1).	Only the motion group set in this program can be set.
Master No.	Set the master robot number. Set the number for the master robot beforehand.	1 - $RK_SETUP.$NUM_MST Don't change these system variables.
Master tool No.	Set the tool frame number used in the program of the master robot. *** At present, this function has not been supported yet. Don't set the value except 0.**	0-5

5. Press [F1] (END) to return the program edit screen.
Teach the motion of the slave robot. In order to synchronize with master program, teach only one point in the slave program. The motion statement in the slave program must be the linear motion. About detail for teaching, refer to the chapter 'Teaching and Robot Link jog'.

```
1: L P [1] 500mm/sec FINE
2: [End]
```

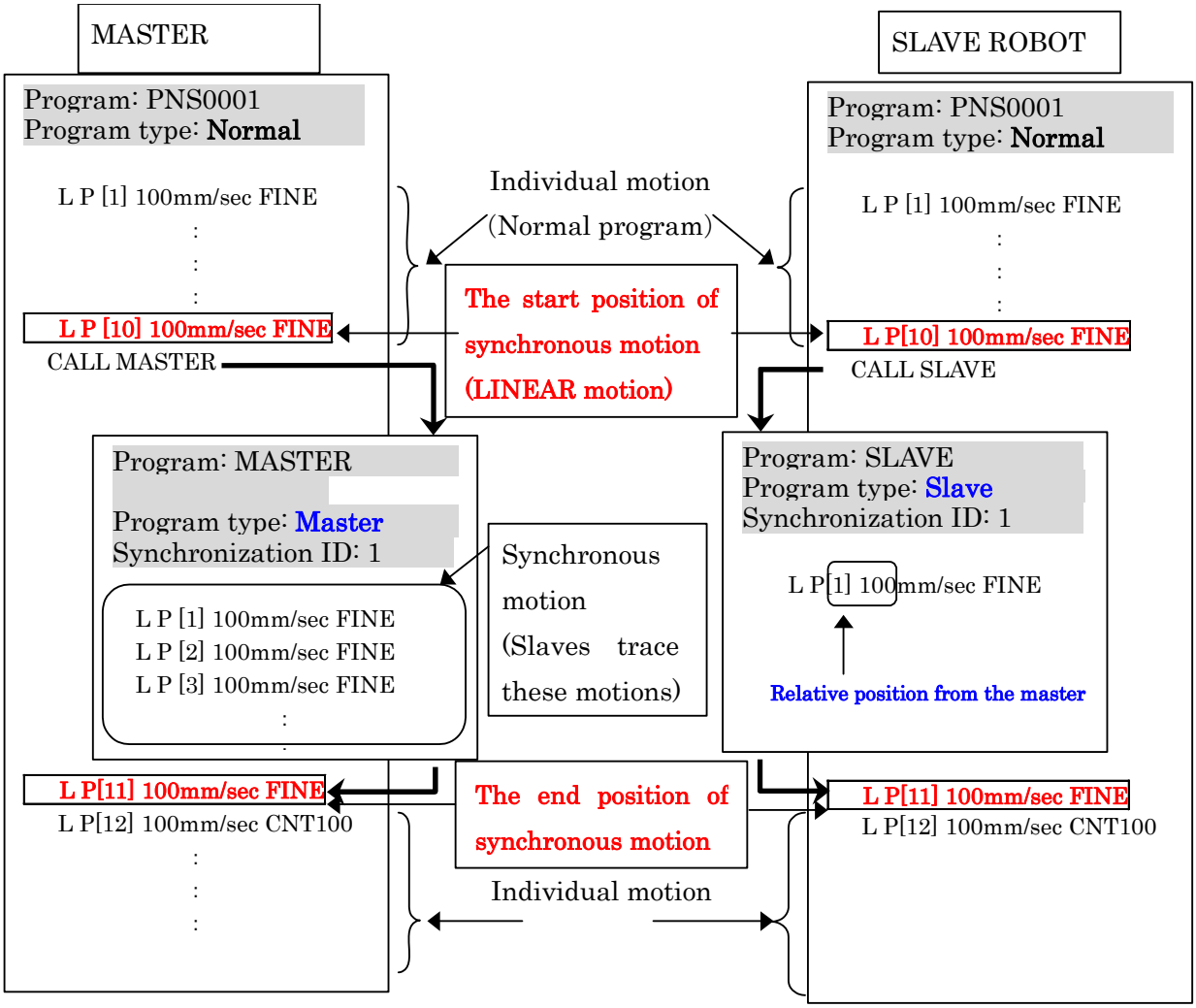
*The speed value of the motion statement in the slave program
The speed value in the slave program is used for the motion that the slave robot moves to the taught position in the program from the current position. If the current position of the slave robot and the taught position in the program are same, this speed value is not used.

NOTE
When the current position of the slave robot is different from the taught position in the program, if the synchronous motion is started, both the return motion to the taught position and synchronous motion with the master robot are executed at same time.

8 RECORDING PROCEDURE AND ROBOT LINK JOG （MANUAL FNCTS screen）

8.1 RECORDING PROCEDURE

Here present the recording procedures of the robot rink. Using the robot rink, two robots are going to hold up one object.



1. **RECORDING PROCEDURE FOR INDIVIDUAL MOTION**
   Before and after the synchronous motion, each robot moves according to one's own program. For the master robot and the slave robots respectively, you need to write the normal program named PNS0001.

2. **MAKING THE MASTER PROGRAM**
   On the master robot, make the master program named 'MASTER', but don't write any orders in it..

3. **MAKING THE SLAVE PROGRAM**
   On the slave robots, make the slave program named 'SLAVE', but don't write any orders in it.

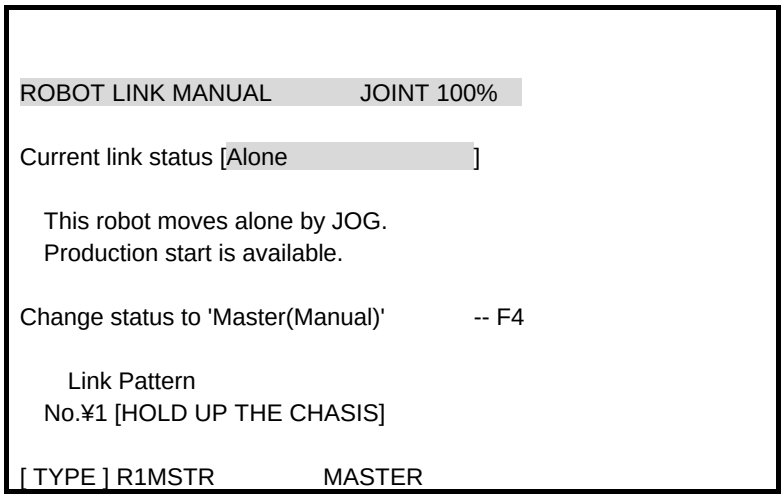
4. **RECORDING THE START POINT OF SYNCHRONOUS MOTION AND CALLING THE SYNCHRONOUS PROGRAM**

To the master robot and the slave robots respectively, record the start point of synchronous motion on the normal program (PNS0001). At the next line, using 'CALL' instruction, call the master program on the master robot's program and the slave program in the slave's robot program respectively.

5. **GETTING THE MASTER ROBOT TO BE MASTER STATUS**

Having the master robot at the start point of synchronous motion, go to the MANUAL FCTNS screen for Robot link on the master robot's teach pendant.

OPERATE > [MANUAL FCTNS] > [Robot Link]



On the MANUAL FCTNS screen, the link status of the motion group you have selected is shown. For the case that the robot has multi groups, it is necessary to confirm that the motion group to be master has been chosen. In this case, please see the sign, [G1] or [G2] in the reverse expression at the upper position on the screen.

If the Current link status is 'Alone' or 'Held', please press the [F4] (MASTER). Then confirm that the status gets to be "Link incomplete" or "Master (Manual)". In such condition that "Current link status [Link incomplete] or [Master (Manual)], we define the master robot is 'Master Status'.

[Link incomplete]: Though it is not complete to synchronize with slave robots, the master robot is 'Master Status'.

[Master (Manual)]: It is possible to do synchronous motion with slave robots on the MANUAL FNCTS screen.

If the current link status is still 'Alone' or 'Held', the setup for the communication or the robot link may be wrong. Please refer to the previous section "Verification of communication and synchronous motion" and confirm the setup.

6. **TEACHING SLAVE PROGRAM**

Having the slave robots at the start point of synchronous motion, record a motion instruction in each slave program. In this positional information, the relative position from the master robot is recorded in this positional information.
Make sure in recording that both master robot and slave robots are at the starting position of synchronous motion.
In the case you have two more slave robots, there need the same procedures above.

At the recording, make sure that no alarm is showed on the teach pendant screen. For example, if you record the start position of synchronous motion to the slave robot when the master robot is not 'Master status', the alarm is shown which indicates the failure of recording position. In this case, the positional information is expressed [****. ***] which indicates 'UNINITIALIZED'.

> **⚠CAUTION**
> Confirm the positional information is not uninitialized after recording the motion instruction in the slave program. Furthermore, do NOT enter positional data directly. Doing so can cause unexpected motion to occur

We cannot write two more motion instructions on the slave program. And if you modify the motion instruction, the alarm will occur. When you would like to change it, you need to delete the motion instruction that has been already recorded and write the new motion instruction once again.

7. ROBOT LINK JOG

In the case to record the synchronous motion, move the robots with synchronous motion using Robot Link jog.
In order to do Robot Link jog, all slave robot need to have these conditions as follows;

- The teach pendant is turned off.
- There is no alarm.
- The robots have not received the HOLD signal. .
- Single step testing is disabled.
- No program is on the running.

Under these conditions, press the key [F4] (MASTER) on the MANUAL FCTNS screen for the Robot link. In the case Current link status is Master (Manual), with the master robot jogging, the slave robots are begin to move tracing the master robot.

But the Current link status is "Link incomplete", even if you jog the master robot; the robots would not begin to motion. In this case, the following operations have to be done.

a. EMERGENCY STOP or HOLD to all robots. （This causes cancellation of slaves' tracking）
b. Cancel the alarm of all robots and fulfill the conditions for Robot Link jog.
c. Press the [F5] (ALONE) on the master robot's 'MANUAL FCTNS' screen.
d. Press the [F4] (MASTER) on the master robot's 'MANUAL FCTNS' screen.

Even after the above procedures, when the Current link status is still Link incomplete, refer to the previous section "Verification of communication and synchronous motion" and try again.

If you would like to jog the master robot alone, press [F5] (ALONE) on the MANUAL FCTNS screen in order that the master robot's status gets to be Alone. In the case you would like to do Robot Link jog again after jogging the robot alone, the following procedures need to be done.

a. EMERGENCY STOP or HOLD to all robots. (This procedure causes cancellation of slaves' tracking.)
b. Cancel the alarm of all robots and fulfill the conditions for Robot Link jog.
c. Press the [F5] (ALONE) on the master robot's 'MANUAL FCTNS' screen.

> **⚠CAUTION**
> During the synchronous motion with Robot Link jog, it can happen that the relative position between the master robot and the slave robots cause a little change. This is because the calibration is not strictly correct. It is impossible for the changes not to occur. Please design the system considering this point.

8. **TEACHING MASTER PROGRAM**

Synchronous motion is recorded on the master program.
Please move the robots by the Robot Link jog and teach the master program.

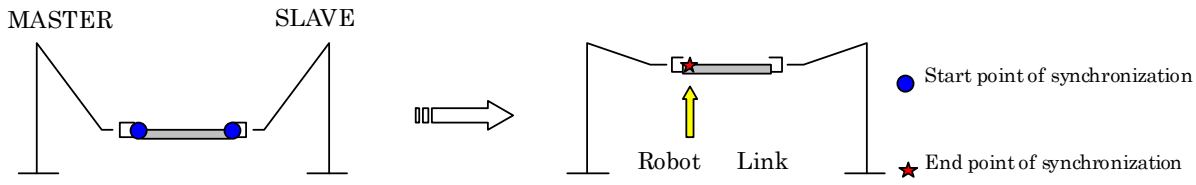
If you run the program when the master robot is Master(Manual) status（which means the Robot Link jog is available）, the slave robots move tracking the master robot.

However, you cannot run the normal program under this condition. If you would like to run the normal program, press [F5] (ALONE) for the master robot to be “Alone” on the MANUAL FCTNS screen for the Robot Link.

In this condition, only on the teach pendant, we can run the program.

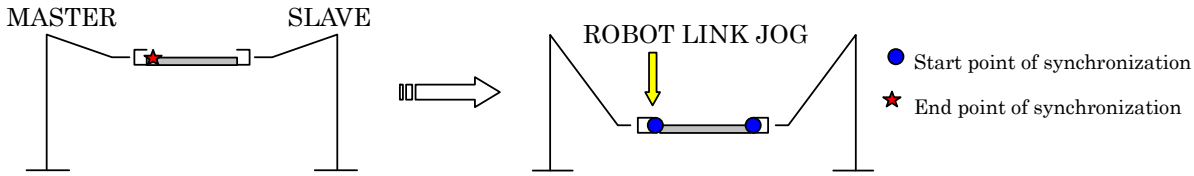
8.2 EXAMPLE

（In the case of using the Robot Link jog from the synchronous start point）
Ordinary method of recording is illustrated below.



（In the case of using the Robot Link jog from the synchronous end point）
During the motions with Robot Link jog, it can happen that the relative position between the master robot and the slave robots makes a little change. This is because the calibration is not strictly correct.

For example, in the case that the end point of synchronous motion is the position to set the work, it is required that the relative position between the master robot and slave robots is more correct. Therefore, first record the synchronous end position. Next, moving the robots form this point to the synchronous start point with Robot Link jog, record this position. See below Figure.



9 RECOVERY FROM THE HALT IN SYNCHRONOUS MOTION

The following section explains the steps to recover when master / slave programs are stopped while performing synchronous motion by EMERGENCY STOP or by some alarm.

9.1 TO RESTART AT THE STOPPED POINT

1. In the synchronous motion, robots are to be halted when they receive such signals that some alarm or EMERGENCY STOP by crossing the sensor or so. Furthermore, in synchronous motion, when even one of them is halted by some reason, (for example, the suspense of communications for the noise or the alarm or hold to the robot), all synchronous robots quit their motion. However, although robots are not moving, the program is still running until you stop it by EMERGENCY STOP or HOLD. In this case you must EMERGENCY STOP to cease running all programs.

   When you have to turn off and on the power supply on the robot controller by some error, record the current cursor position on the running program before turning off. After booting verify that the program is paused at the same position before turning off and on.（This procedure is available only when Use HOT START is TRUE.）
   If you find that the program is ended, please recover the system by the following procedure: moving all robots to original position to run successively or moving to the safety position with Robot Link jog. See next subsection.

2. In the case that the robots are halted by EMERGENCY STOP, because there are some differences of the distance for each robots to stop, it can occur that the relative position of the robots now are different from one at the start position of synchronization. Therefore, you need to see to confirm the current robot position. If there is a little difference, you don't have to be careful, because the robots begin to motion returning to the recorded position. If there is much difference, it is necessary to move the robot respectively. Please follow these procedures to recover.

   In the case of master robot Turning on the teach pendant, press the key [MENUS] > [3.MANUAL FNCTS] > [F1] (TYPE) > [Robot Link] > [F5] (Alone). After confirming that the current link status is 'Alone' you may move the robot alone with jogging. If you try to jog the robot when the status is 'Link incomplete' or 'Held (master)', the robot does not move and the following alarm would be posted.
   MOTN-212 Link is in held status (G:i)

   In the case of slave robot Turning on the teach pendant, press the key [MENUS] > [3.MANUAL FNCTS] > [F1] (TYPE) > [Robot Link] > [F5] (Alone). After confirming that the current link status is 'Alone' you may move the robot alone with jogging. If you try to jog the robot when the status is 'Held (slave)', the robot does not move and the following alarm would be posted.
   MOTN-212 Link is in held status (G:i)

3. Please run the program again. Both the master robot and slave robots will run the synchronous program, automatically synchronizing.

9.2 RETURN ALL ROBOTS TO THE RESPECTIVE ORIGINAL POSITION

1. Please stop all robots' running program by EMERGENCY STOP.

2. In the case of master robot Turning on the teach pendant, press the following keys [MENUS] > [3.MANUAL FNCTS] > [F1] (TYPE) > [Robot Link] > [F5] (ALONE). After the current link status become Alone, move the robot with jogging. Master robot will move alone. You can run the 'HOME' program (which is normal program to return the original position) from the teach pendant.

   In the case of slave robot Turning on the teach pendant, press the following keys [MENUS] > [3.MANUAL FNCTS] > [F1] (TYPE) > [Robot Link] > [F5] (ALONE). After the current link status become Alone, move the robot with jogging. Slave robot will move alone. You can run the 'HOME' program (which is normal program to return the original position) from the teach pendant.

3. After all robots return to the respective original position, run the system.

9.3 MOVE THE ROBOT TO THE SAFETY POSITION WITH ROBOT LINK JOG

It is dangerous to operate each robot respectively to recover from the halt when the robots are handing an object with robot link synchronous motion. Follow these operations to move the robots where they unload the object.

It may happen that the system is halted when the robots are handling the object without using Robot link proceeding with rail axes. In this case, you should continue the program until the rail axes reach the destination points (This is the position for the robot to start the next synchronous motion).

1. EMERGENCY STOP to halt running all robots' program.
2. Reset the alarm of all slave robots to fulfill these conditions for the Robot Link jog as follows;
   - The teach pendant is turned off.
   - No alarm.
   - No HOLD signs.
   - Single step testing is disabled.
   - No program is running.
3. If the current link status on the master robot is not Alone on 'the Robot link MANUAL FNCTS', press the key [F5] (ALONE).
   Confirm that the Current link status becomes Alone.
4. Press the key [F4] (MASTER) on the Robot Link MANUAL FNCTS.
   Confirm that the Current link status becomes Master (Manual).
5. With the master robot jogging, all slave robots follow the master robot. By using this Robot Link jog, move the robots to the safe position or the place where robots can unload the workpiece.
6. Press [F5] (ALONE) on 'the Robot Link MANUAL FNCTS' screen of the master robot and confirm that the current link status becomes Alone.
7. EMERGENCY STOP to all robots (This procedure forces slave robots to cancel tracking).
8. In the case you would like to continue the program from this position, reset the alarm and do it.

   In another case you would like to execute the program from home position, please jog each robot to the home position. Please refer to section 9.2 for detailed operation. Each robot should move individually.

Original path resume feature:

Original path resume feature is available for some applications. The robot behaves differently depending on ENABLE / DISABLE of this feature as follows.
Please refer to the manual of each application for the operation to enable (or disable) original path resume, because each application has the different user interface.

- Disable case:

Each robot will resume synchronization at the current position when you resume the synchronous motion. If you jog robots away and resume the program, the synchronization will be established at the different position from original held positions.

- Enable case:
  Each robot will move back to the original held position before retrieve synchronization when you resume the synchronous motion. In this case, every robot will come back to each original held position even though you jog away robots. And the synchronization will be established at the different position.

NOTES:

- This feature works only when the master program is executed by external start signal. If you resume it from Teach pendant, robots behave as the same way as 'DISABLE' case.

- The original path resume feature should be enabled for all robots linked by robot link function. Otherwise, the following alarm would be posted at resuming the synchronous motion.
  "MOTN-214 Resume condition mismatch"

- If robots lose the synchronization during holding procedure such as Emergency stop case, robots move back to that positions which lost synchronization. If the position error is not acceptable, please adjust each robot position before resuming the program. Please refer to 9.1 and 9.3 for the operation. And resume the master program from Teach pendant so that all robots behave as the same way as 'DISABLE' case. Please verify that the synchronization is established at the current position, then halt the master program again and resume the program from external start signal. In this case, the slave robots may keep moving to retrieve the desired relative position relationship with master.

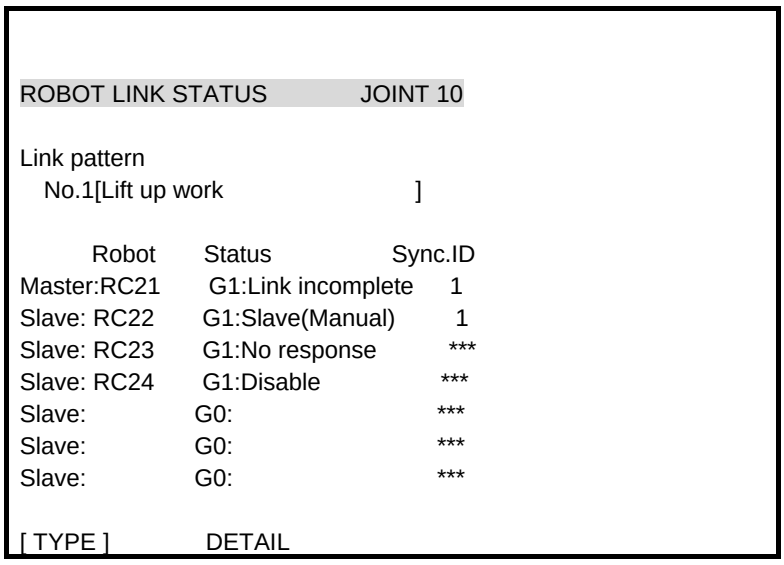
- Robots don't synchronize each other until all robots move back to the original held position. If you jog away robots too far, robots may collide each other. Please make sure that all robots are close enough to the original held position before resuming the program.

- Resume distance feature is not available during synchronous motion. This distance will be ignored without any alarm. This feature is available for non-synchronous motion.

10 STATUS SCREEN

Status screen provides information on the state of the connection between the master robot and the slave robots. Use following procedure to display the robot link status screen.

Press [STATUS] (User key) > Press [F1] [TYPE] > Select Robot Link



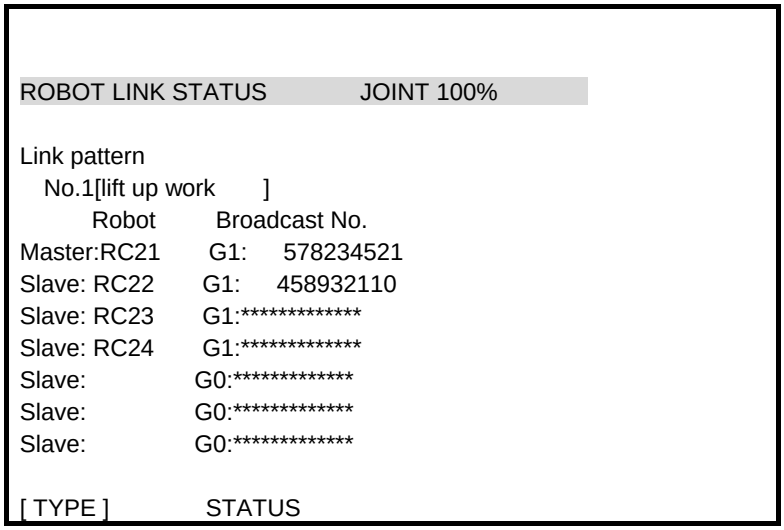
Master has following status items.

- Master(Manual) : The master robot is in master status operated from ROBOT LINK MANUAL screen and the link to all slave robots are established. Sync. ID becomes 0.
- Master(Program) : The master robot is in master status because a master program is running and the links to all slave robots are established.
- Link incomplete : The master robot is in master status. But the links to all slave robots are not established.

Slave has following status items.

- Slave(Manual) : The slave robot is in slave status operated from the ROBOT LINK MANUAL screen on the master robot.
- Slave(Program) : The slave robot is in slave status because a slave program is running.
- Disable : The slave robot is in Disable status because the slave robot is disabled from LINK PATTERN screen on the master robot.
- No response : The slave robot does not respond. The robot may not be in slave status.

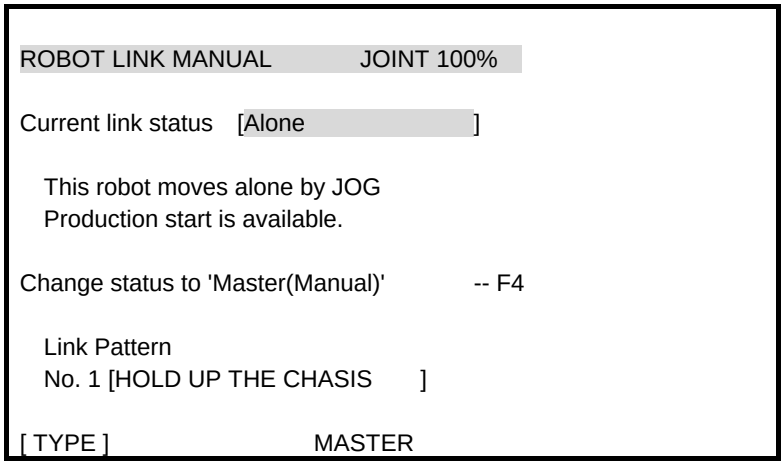
Press [F3] (DETAIL) to see following screen.


ROBOT LINK STATUS JOINT 100%
Link pattern
No.1[lift up work]
Robot Broadcast No.
Master:RC21 G1: 578234521
Slave: RC22 G1: 458932110
Slave: RC23 G1:**********
Slave: RC24 G1:**********
Slave: G0:**********
Slave: G0:**********
Slave: G0:**********
[TYPE] STATUS

11 MANUAL FUNCTION SCREEN

Manual Function (MANUAL FCTNS) screen provides information of the link status of each robot and you can change the status from this screen. Robot Link jog should be enabled on this screen.
Please use the following procedure to display the robot link manual function screen.

OPERATE: [MENU] > [MANUAL FCTNS] > Press [F1] [TYPE] > Select [Robot Link]



There are the following several types of “Current link status”.
ALONE:

- Alone: Alone status. Jog motion is available. Each robot moves individually. You can change the status by pressing [F4] (MASTER) key. The specified link pattern at “link pattern” would be used for the synchronization. (No.1 in the above case.)

MASTER:

- Master (Manual): Manual master status. Master robot becomes this status by pressing [F4] (MASTER) key on this screen. Jog motion is available. The synchronization is currently established. All slave robots follow the master robot.
- Master (Program): Program master status. Master robot becomes this status by establishing the synchronization during program execution. Jog motion is available. The synchronization is currently established. All slave robots follow the master robot.
- Link incomplete: The synchronization is not established even though master robot is ready for the synchronization. Jog motion is not available. Please change status by pressing either [F4] (MASTER) key or [F5] (ALONE) key.
- Held (Master): Some robots were held during synchronization. Jog motion is not available. Please change the status by pressing either [F4] (MASTER) key or [F5] (ALONE) key.

SLAVE:

- Slave (Manual): Manual slave status. Slave robots become this status when master robot becomes Manual master. Jog motion is not available. The synchronization is currently established. This robot follows master robot. Please change the status by pressing [F5] (ALONE).
- Slave (Program): Program slave status. Slave robots become this status by establishing the synchronization during program execution. Jog motion is not available. The synchronization is currently established. All slave robots follow master robot.
- Held (Slave): Some robots were held during synchronization. Jog motion is not available. Please change the status by pressing [F5] (ALONE) key.

12 TROUBLESHOOTING

12.1 SYNCHRONIZED MOTION DOES NOT START. THE ROBOTS HAVE STOPPED WHILE SYNCHRONIZED MOTION

1. Display ROBOT LINK STATUS screen on the teach pendant of the master robot.
   Press [STATUS] (User key) > Press [F1] [TYPE] > Select Robot Link
2. ROBOT LINK STATUS screen provides the status information among the linked robots as follows. First, confirm the communication status whether good or not with this screen.

```
ROBOT LINK STATUS                JOINT100%
  No.1 [Lift up work                 ]
         Robot       Status            Sync.ID
Master:RC21     G1:Master(Program)       1
Slave: RC22     G1:Slave(Program)        1
Slave: RC23     G1:Slave(Program)        1
Slave: RC24     G1:Slave(Program)        1
Slave:          G0:                      ***
Slave:          G0:                      ***
Slave:          G0:                      ***

[ TYPE ]          DETAIL
```

   This example screen shows good status.

3. When synchronized motion does not start, or if the robots have stopped while synchronized motion, the status of the slave robot on ROBOT LINK STATUS screen will be displayed as ‘No response’. As the following screen.

```
ROBOT LINK STATUS                JOINT 100%
Current Link Pattern                1/5
  No.1 [Lift up work                 ]

         Robot          Status        Sync.ID
Master:RC21     G1:Master(Program)       1
Slave: RC22     G1:Slave(Program)        1
Slave: RC23     G1:No response          ***
Slave: RC24          G1:Slave(Program)        1
Slave:               G0:                      ***

[ TYPE ]          DETAIL
```

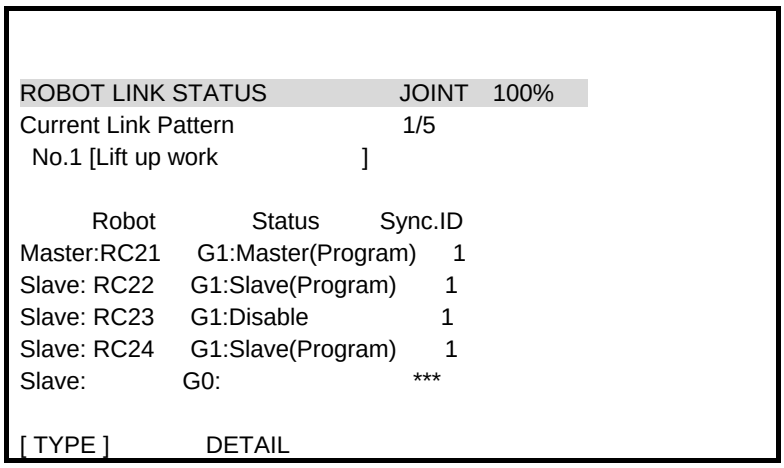
   In these circumstances, follow the next procedure.

   (1) E-Stop all robots. Cut the power of the switching hub and connect the power. After that, try to restart the program and confirm whether the synchronized motion recovers or not.

(2) If the synchronized motion does not recover with0, after E-Stop all robots, cut the power of the robot controllers that are displayed as 'No response' on ROBOT LINK STATUS screen and connect the power. After that, try to restart the program and confirm whether the synchronized motion recovers or not.

12.2 THE SLAVE ROBOT THAT SHOULD SYNCHRONIZE DOES NOT SYNCHRONIZE.

1. Display ROBOT LINK STATUS screen on the master robot's teach-pendant.
   Press [STATUS] (User key) > Press [F1] [TYPE] > Select Robot Link
2. When a slave robot does not synchronize with others, the status of the slave robot on ROBOT LINK STATUS screen will be displayed as 'Disable'. As the following screen.



In these circumstances, follow the next procedure.

(1) If Status is 'Disable', the slave robot's Link setting that is specified in Link pattern setting screen at master robot's controller must be 'SEPARATE'.
Change this setting from 'SEPARATE' to 'CONNECT'. Cut the power of the master robot's controller and connect the power. After that, restart the program and confirm whether the synchronized motion recovers or not.

(2) If the slave robot that is not synchronize with others is not displayed in ROBOT LINK STATUS screen, perform the setup for that slave robot on Link pattern setup screen at master robot's controller.
Cut the power of the master robot's controller and connect the power. After that, restart the program and confirm whether the synchronized motion recovers or not.

12.3 ROBOT CANNOT BE JOGGED AFTER HOLDING DURING SYNCHRONIZATION.

1. Jog motion is not available without special operation under hold condition to avoid any unexpected loss of synchronization because of jog motion by mistake.
2. Select MANUAL FCTNS screen ([MENUS] > [3 MANUAL FCTNS] > [F1] (TYPE) > Robot Link). Please select either [F4] (MASTER) or [F5] (ALONE) depending on the jog type, which you need. Please jog the robot after verifying that the status has been changed to either of "Master (Manual)" or "ALONE". The following alarm would be posted and robot does not move if you try to jog the robot under either status of "Link incomplete", "Held (Master)" or "Held (Slave)".
   MOTN-212 Link is in held status (G:group number)

12.4 ORIGINAL PATH RESUME FEATURE DOESN'T WORK EVEN IF IT IS ENABLED.

1. Robots behave as the same way as original path resume "DISABLE" case at resuming the program if the master program is resumed from TP ([SHIFT]+[FWD]).
2. Please jog and move all the robots back to the original held position manually, and resume the program from TP.
3. Please resume the master program using external start signal instead of TP operation to enable original path resume feature.

13 RECOVERY METHOD WITHOUT MANUAL PROCESS

When robots are stopped while synchronized motion, you can recover the motion manually with the procedure described in 'Recovery from the halt in synchronous motion'. But manual process may cause operator's mistake. This section explains about the recovery method without manual process.

Example) With several robots, lift up a work with synchronized motion, move the work horizontally driving the rail unit on which all robots are mounted, and put down the work with synchronized motion.

The line is stopped.

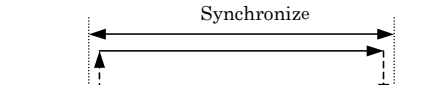
- The line can be restarted → Normal restart

(Set up status lamp showing whether the line can restart or not.)

- The line cannot be restarted.
  - Out of synchronized motion area. → Manually move each robot to start point and restart the program.

(Set up status lamp showing whether the robot are while synchronized motion or not.)

  - In synchronized motion area.
    - Discharges the work pressing the robot link recovering buttons that is placed on operator control panel.



		UP	SLIDE		DOWN	
Button	LEFT	RIGHT	⇦	⇨	LEFT	RIGHT
MASTER	PNS0101	PNS0102	PNS0201	PNS0202	PNS0301	PNS0302
SLAVE	PNS0101	PNS0102			PNS0301	PNS0302
SLAVE	PNS0101	PNS0102			PNS0301	PNS0302
SLAVE	PNS0101	PNS0102			PNS0301	PNS0302

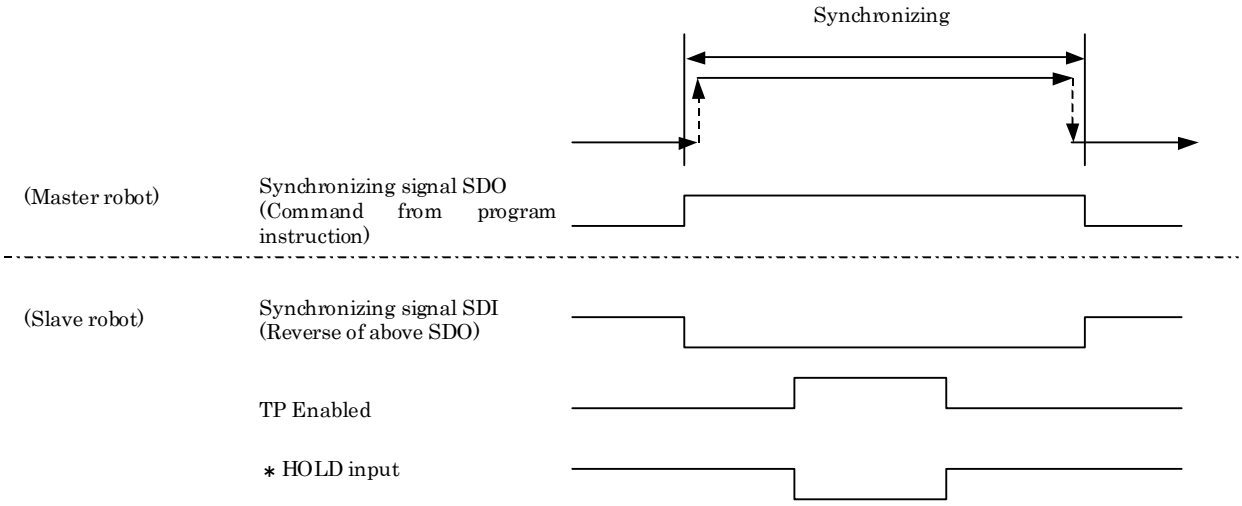
Discharge programs for each kind of work

Discharge work

Discharges the work by pressing the robot link recovering buttons that is placed on operator control panel.

- Prohibit manual control on slave robot

  In synchronized motion area, prohibit manual operation such as program execution or jogging from slave robot's teach-pendant. (This function can put into practice with PMC radar.)



APPENDIX

A ALARM CODES

This section lists the alarm codes of the robot link function.

INTP-450 Cannot call KAREL program
Cause: Master/Slave/Slave Alone program called KAREL program.
Remedy: Master/Slave/Slave Alone program cannot call KAREL program.

INTP-451 Cannot call Motion program
Cause: Master/Slave/Slave Alone program called Normal program that has motion group.
Remedy: Master/Slave/Slave Alone program cannot call Normal program that has motion group.

INTP-452 Robot link type mismatch
Cause: Master/Slave/Slave Alone program called different type of program.
Remedy: Master/Slave/Slave Alone program can call only same type of program.

INTP-453 Not in remote
Cause: Slave program cannot be executed without remote status.
Remedy: Satisfy the remote condition

INTP-454 Illegal return occurred
Cause: Program type is different between caller program and called program.
Remedy: Program type of caller program is the same as that of called program.

INTP-455 Group mismatch (Link pattern)
Cause: Master program does not have the same motion group which is specified by the link pattern of robot link data.
Remedy: Master program must have the same motion group which is specified by the link pattern of robot link data.

INTP-456 Group mismatch (Slave group)
Cause: Slave program does not have the same motion group that is specified by the slave group of robot link data.
Remedy: Slave program must have the same motion group that is specified by the slave group of robot link data.

INTP-457 Master tool number mismatch
Cause: Current tool frame number of master robot is different from the master tool No of robot link data of the slave program.
Remedy: Current tool frame number of master robot and the master tool No of robot link data of the slave program must be same number.

INTP-458 Robot is still moving
Cause: Since robot is still moving, it is impossible to synchronize.
Remedy: After robot stops completely, continue the program again.

INTP-459 Slave cannot JOINT motion
Cause: The motion statement of slave program is JOINT motion.
Remedy: Change the motion statement of slave program to LINEAR motion.

INTP-460 Cannot use JOINT position
Cause: The position data of slave program is JOINT type.
Remedy: Change the position data of slave program to LINEAR type.

INTP-461 Master TP is enabled
Cause: Master program is executed by TP. Slave program is paused.
Remedy: Slave program is paused, when master program is executed by TP.

INTP-462 Cannot start Robot Link
Cause: Robot link setup may be wrong.
Remedy: Confirm the robot link setup.

INTP-463 Motion group is master
Cause: The motion group of specified program becomes to be master.
Remedy: Change the robot to normal from master. Then, please try to execute again.

INTP-464 Motion group is slave
Cause: The motion group of specified program becomes to be slave.
Remedy: Change the robot to normal from slave. Then, please try to execute again.

INTP-465 Tracking error
Cause: Tracking of slave program is failed.
Remedy: Confirm the robot link setup.

INTP-466 Robot link not calibrated
Cause: Robot link calibration has not been done yet.
Remedy: Calibrate the robot link.

INTP-467 Cannot use INC for Slave
Cause: The slave program cannot use Incremental instruction.
Remedy: Remove the Incremental instruction.

INTP-468 Cannot use OFFSET for Slave
Cause: The slave program cannot use Offset instruction.
Remedy: Remove the Offset instruction.

INTP-469 BWD is failed for Master
Cause: Synchronize of Master is failed for BWD.
Remedy: Change the Slave robot to synchronization waiting status.

INTP-470 Not support BWD for Slave
Cause: BWD of Slave program is not supported.
Remedy: BWD of Slave program is not supported.

INTP-471 Robot is Master (Manual)
Cause: Current status of the robot is Master (Manual).
Remedy: When robot is Master (Manual), you cannot use external program execution. To use external program execution, please change the status to Master (Alone) at the manual operation screen.

INTP-472 Robot is Slave (Manual)
Cause: Current status of the robot is Slave (Manual).
Remedy: When robot is Slave (Manual), you cannot execute other Slave program. To execute other Slave program execution, please hold the program to exit Slave (Manual) status.

INTP-473 Synchro ID is ZERO
Cause: The synchro ID of the specified program is zero.
Remedy: Synchro ID 0 is not available number. Please set another synchro ID.

INTP-474 Synchro ID mismatch
Cause: The program whose synchro ID is different from current synchro ID is executed.
Remedy: Please change the synchro ID to fit the current synchro ID.

INTP-475 Cannot single step
Cause: Slave program cannot use single step execution.
Remedy: Please release single step key.

INTP-476 BWD is failed
Cause: BWD is failed.
Remedy: The other alarm occurs at the same time and it shows cause.
Open alarm history screen and check the alarm that occurred just after this alarm.

INTP-477 Cannot run Slave directly
Cause: Slave program cannot be executed directly.
Remedy: Slave program must be called by normal program.

INTP-478 This group cannot be MASTER
Cause: This motion group is not specified as master in SETUP.
Remedy: Use another group as master or change SETUP.

INTP-479 Bad Hostname or Address (MASTER)
Cause: HOSTNAME, IP Address or group number about MASTER is not correct.
Remedy: Confirm Robot Link and HOST Comm TCP/IP SETUP.

INTP-480 Bad Hostname or Address (SLAVE)
Cause: HOSTNAME, IP Address or group number about SLAVE is not correct.
Remedy: Confirm Robot Link and HOST Comm TCP/IP SETUP.

INTP-481 Bad Synchronization ID
Cause: Synchronization ID in program is invalid.
Remedy: Modify Synchronization ID at Program List Screen.

INTP-482 Bad Link Pattern Number
Cause: Link Pattern Number in program is invalid.
Remedy: Modify Link Pattern Number at Program List Screen.

INTP-483 Bad Master Number
Cause: Master Number in program is invalid.
Remedy: Modify Master Number at Program List Screen.

INTP-484 Bad Group number (MASTER)
Cause: Specified group number about MASTER is invalid.
Remedy: Confirm group number setup about MASTER.

INTP-485 Bad Group number (SLAVE)
Cause: Specified group number about SLAVE is invalid.
Remedy: Confirm group number setup about SLAVE.

INTP-486 SLAVE is not calibrated
Cause: Specified SLAVE is not calibrated.
Remedy: Calibrate SLAVE robot.

INTP-487 No Valid Slave in Link Pattern
Cause: No valid SLAVE is specified in Link Pattern data.

Remedy: Confirm Link Pattern at Robot Link SETUP screen.

INTP-488 RLINK communication timeout
Cause: At comm-buffer init, comm-processor is too busy.
Remedy: Increase $RK_SYSCFG.$RMGR_PHTOUT by 100.

INTP-489 Bad Hostname or Address, Group
Cause: Hostname or IP Address, Group number setup is invalid.
Remedy: Check HOST Comm TCP/IP and Robot Link SETUP.

INTP-490 Timeout for link start
Cause: Hostname or IP Address, Group number setup may be invalid.
Or another link robot is not running robot link program.
Remedy: Check HOST Comm TCP/IP and Robot Link SETUP, and another robot's status.

INTP-491 Linked robot or comm stopped
Cause: Another robot's link program is paused.
Or communication stopped by power fail or another cause.
Remedy: Check another robot's status.

INTP-492 Master program stopped
Cause: When the robot is slave status, master robot's link program is stopped.
Remedy: Check master robot's status.

INTP-493 Slave program stopped
Cause: When the robot is master status, slave robot's link program is stopped.
Remedy: Check slave robot's status.

MOTN-173 Robot link configuration error
Cause: Robot Link setup is not correct.
Remedy: Confirm the host names / IP addresses at HOST COMMUNICATION and Robot Link Setup.

MOTN-174 No motion control
Cause: Forced to be master or slave while robot is moving with running a normal program or jogging
Remedy: Operate after aborting the normal program.

MOTN-175 Failed to be MASTER
Cause: When the robot is forced to be master with a master program calling or manual operation, the robot has not done previous motion yet. Or the setup of Robot Link is wrong.
Remedy: Modify the program or check the Robot Link setup.

MOTN-176 Failed to be SLAVE
Cause: When the robot is forced to be slave with a slave program calling or manual operation, the robot has not done previous motion yet. Or the setup of Robot Link is wrong.
Remedy: Modify the program or check the Robot Link setup.

MOTN-177 Failed to end sync motion
Cause: Cannot stop the synchronized motion when the master robot or the slave robot is not stopped or when the Robot Link setup is wrong.
Remedy: Confirm the motion instruction on the program and the Robot Link setup.

MOTN-178 Link robot is HELD
Cause: While synchronized motion, the linked robot became to alone state for example because of program holding.

Remedy: The program will be held. Re-start the mater and slave programs.

MOTN-180 Robot Link Calib-data not found
Cause: There is no calibration data.
Remedy: Please perform the calibration for the robot link.

MOTN-181 Robot Link Version mismatch
Cause: The software version of the master robot is different from that of the slave robot.
Remedy: Please match software version.

MOTN-182 Failed to get data from master
Cause: The translation data from the master robot has not translated.
Remedy: Please check the Ethernet cable, connection, HUB, Mainboard or the setup of the robot link.

MOTN-183 Invalid MNUTOOLNUM data array
Cause: The data array of $MNUTOOLNUM is invalid.
Remedy: Please check the $MNUTOOLNUM.

MOTN-184 Invalid MNUTOOL data array
Cause: The data array of $MNUTOLL is invalid.
Remedy: Please check the $MNUTOOL.

MOTN-185 Protect of ACK BF to be sent
Cause: The translation memory in the slave from the slave robot to the master robot is protected.
Remedy: No action. This is not a problem.

MOTN-186 Protect of BCST BF to be sent
Cause: The translation memory in the master robot from the master robot to the slave robot is protected.
Remedy: No action. This is not a problem.

MOTN-187 Protect of ACK BF to be read
Cause: The translation memory in the master from the slave robot to the master robot is protected.
Remedy: No action. This is not a problem.

MOTN-188 Protect of BCST BF to be read
Cause: The translation memory in the slave robot from the master robot to the slave robot is protected.
Remedy: No action. This is not a problem.

MOTN-189 Slave motion remained
Cause: For the slave robot, there is the rest of the previous motion at the start of the slave program.
Remedy: Please re-start after the previous motion.

MOTN-190 Slave cannot use JOINT pos
Cause: In the slave program the Joint position type for the motion statement is not executed.
Remedy: Please change to the Cartesian position type.

MOTN-191 Slave cannot JOINT motion
Cause: In the slave program the JOINT motion is not executed.
Remedy: Please change to the Linear/Circular motion.

MOTN-192 UT of MASTER was changed
Cause: During the master status, the Utool of master robot is changed.
Remedy: Don’t change the Utool of master robot during the master status.

MOTN-193 UT of SLAVE was changed
Cause: During the slave status, the Utool of slave robot is changed.
Remedy: Don't change the Utool of slave robot during the slave status.

MOTN-194 Machine Lock is ENABLED
Cause: In machine lock status the robot link is disabled.
Remedy: Please release the machine lock status.

MOTN-210 Failed to resume program
Cause: Original Path Resume was used for Robot Link.
But Resume condition was not satisfied.
Remedy: Abort and re-run the program.

MOTN-212 Link is in held status (G:i)
Cause: Jog motion of the 'i'th group robot in the status of Held or Link Incomplete is not allowed.
Remedy: Change status to MASTER or ALONE at MANUAL screen to jog the robot.

MOTN-213 Org path resume not available
Cause: Original path resume feature is not available under this configuration.
Remedy: Disable original path resume feature.

MOTN-214 Resume condition mismatch
Cause: Resume condition does not match between master and slaves
Remedy: Check if original path resume is enabled, and match the resume condition for all robots.
If some had been aborted and some are resume condition, this alarm may occur, because the resume condition does not match for all robots.

ADDITIONAL INFORMATION

Addition for FANUC Robot series R-30*i*A/R-30*i*A Mate CONTROLLER
Robot Link OPERATOR'S MANUAL

1.Type of applied technical documents

Name	FANUC Robot series R-30*i*A/R-30*i*A Mate CONTROLLER Robot Link OPERATOR'S MANUAL
Spec.No./Ed.	B-82924EN/01

2.Summary of Change

Group	Name/Outline	New, Add, Correct, Delete	Applicable Date
Basic			
Optional Function	Description of Set up for Synchronizing Controlled Stop Motion is added. Description of Limitations on Software is added.	Add	Immediately
Unit			
Maintenance Parts			
Notice			
Correction			
Another			

						Title	Addition for FANUC Robot series R-30iA/R-30iA Mate CONTROLLER Robot Link OPERATOR'S MANUAL
						Draw No.	B-82924EN/01-1
01	12.08.28	Sugio	Initial Release			FANUC CORPORATION	Sheet 1/2
Ed.	Date	Design	Description				
Date	12.08.28	Desig.	Sugio	Check	Apprv.		

Please add the following after “4.3.6 Set up acceleration time during synchronous motion”

4.3.7 Set Up for Synchronizing Controlled Stop Motion

Please set system variables by the following procedure in order to synchronize Controlled Stop motion.

(1) Please check the maximum value of $SCR.$HW_C1_TIME on controllers
(2) Please set the checked maximum value to $SCR.$HW_C1_TIME on each controller.
(3) Please check the maximum value of $SCR.$HW_C2_TIME on controllers
(4) Please set the checked maximum value to $SCR.$HW_C2_TIME on each controller.
(5) Please power off/on after system variables is set.

NOTE
When $SCR.$HW_C1_TIME,$SCR.$HW_C2_TIME is changed to larger value, the coast distance by controlled stop is extended regardless of the motion.

Please add the following before “2.1 LIMITATIONS ON OTHER SOFTWARE OPTIONS”

2.1 LIMITATIONS ON SOFTWARE

When you use this software, software series and version of all controllers must be the same.

Ed.	Date	Design	Description
01	12.08.28	Sugio	Initial Release

Date	12.08.28	Desig.	Sugio	Check		Apprv.	

Title	Addition for FANUC Robot series R-30iA/R-30iA Mate CONTROLLER Robot Link OPERATOR’S MANUAL
Draw No.	B-82924EN/01-1

FANUC CORPORATION

Modification for FANUC Robot series R-30iA/R-30iA Mate CONTROLLER
Robot Link OPERATOR'S MANUAL

1.Type of applied technical documents

Name	FANUC Robot series R-30iA/R-30iA Mate CONTROLLER Robot Link OPERATOR'S MANUAL
Spec.No./Ed.	B-82924EN/01

2.Summary of Change

Group	Name/Outline	New, Add, Correct, Delete	Applicable Date
Basic			
Optional Function	Description for calibration is modified.	Modify	Immediately
Unit			
Maintenance Parts			
Notice			
Correction			
Another			

Ed.	Date	Design	Description
01	15.02.18	K.Takaki	Initial Release

Date 15.02.18 Desig. K.Takaki Check Apprv.

Title	Modification for FANUC Robot series R-30iA/R-30iA Mate CONTROLLER Robot Link OPERATOR'S MANUAL
Draw No.	B-82924EN/01-2
FANUC CORPORATION	Sheet 1/2

This below description is modified.

5.3 CALCULATION OF CALIBRATION DATA

2. Please transport the TP programs that are recorded three reference points to PC via Memory card or MS-DOS formatted floppy disc.

2. Please transport the TP programs that are recorded three reference points to PC via Memory card or USB Memory. However, you should set a name of each calibration program within 8 characters. The calibration tool does not support long file name which is longer than 8 characters.

						Title	Modification for FANUC Robot series R-30iA/R-30iA Mate CONTROLLER Robot Link OPERATOR'S MANUAL
						Draw No.	B-82924EN/01-2
01	15.02.18	K.Takaki	Initial Release			FANUC CORPORATION	Sheet 2/2
Ed.	Date	Design	Description				
Date	15.02.18	Desig.	K.Takaki	Check	Apprv.		

FANUC Robot Series R-30*i*A/R-30*i*A Mate CONTROLLER Robot Link Operator's Manual
Support both R-30***i***A and R-30***i***B

1.Type of applied technical documents

Name	FANUC Robot Series R-30*i*A/R-30*i*A Mate CONTROLLER Robot Link Operator's Manual
Spec.No./Ed.	B-82924EN/01

2.Summary of Change

Group	Name/Outline	New, Add, Correct, Delete	Applicable Date
Basic			
Optional Function			
Unit			
Maintenance Parts			
Notice			
Correction			
Another	Modified to support both R-30*i*A and R-30*i*B. Mainly changed description about safety and RIPE setting.	Correct	Immediately

						Title	FANUC Robot Series R-30iA/R-30iA Mate CONTROLLER Robot Link Operator's Manual Support both R-30iA and R-30iB
						Draw No.	B-82924EN/01 - 3
01	2016.4.11	T. Hannya	Initial release			FANUC CORPORATION	Page 1/10
Ed.	**Date**	**Design**	**Description**				
Date		**2016.4.11**	**Design.**	**T. Hannya**	**Apprv.**		

"R-30iB/R-30iB Mate" was added in title

FANUC Robot series

R-30*i*A / R-30*i*A Mate / R-30*i*B / R-30*i*B Mate CONTROLLER

Robot Link

OPERATOR'S MANUAL

B-82924EN/01

						Title	FANUC Robot Series R-30iA/R-30iA Mate CONTROLLER Robot Link Operator's Manual Support both R-30iA and R-30iB
						Draw No.	B-82924EN/01 - 3
01	2016.4.11	T. Hannya	Initial release				
Ed.	**Date**	**Design**	**Description**			**FANUC CORPORATION**	Page 2/10
Date		**2016.4.11**	**Design.**	**T. Hannya**	**Apprv.**		

1 INTRODUCTION

Change

This manual describes the setup and use of **Robot Link on R-30iA / R-30iA Mate and R-30iB / R-30iB Mate controllers** using V7.20P/20 or higher software. If your system uses older controller models (R-J3 or R-J3iB), Do NOT use this manual.
You need to use an earlier version of the Robot Link User's Manual.

- This software enables several robots to perform synchronous motion between several controllers by Ethernet network. FANUC **R-30iA / R-30iA Mate and R-30iB / R-30iB Mate** robot controller has Ethernet hardware as a basic functionality.

Change

				Title	FANUC Robot Series R-30iA/R-30iA Mate CONTROLLER Robot Link Operator's Manual Support both R-30iA and R-30iB	
				Draw No.	B-82924EN/01 - 3	
01	2016.4.11	T. Hannya	Initial release			
Ed.	Date	Design	Description	FANUC CORPORATION	Page	3/10
Date	2016.4.11	Design.	T. Hannya	Apprv.		

Word “R-30iB” was added in “2.3 Network configuration for R-J3iC controllers”. Misspelling was corrected.
Please see bold characters.

Change

2.3 Network configuration for **R-30iA / R-30iA Mate and R-30iB / R-30iB Mate** controllers:

Change

- The **R-30iA / R-30iA Mate and R-30iB / R-30iB Mate** controller provides two Ethernet ports on the CPU PC board. In prior controller versions, it was necessary to provide isolation of Ethernet ports from the factory Ethernet trunk during Robot Link operations. The “B” channel of the CPU is a high priority Ethernet port, this port is used to support the “private network” for Robot Link communication.
- The following figure is example of network configuration for robot link as supported on **R-30iA / R-30iA Mate and R-30iB / R-30iB Mate** controllers. The robot link network is configured on the high priority, channel B Ethernet line of the master and slave controllers. Trunk line communications are configured on the channel A line of the **R-30iA / R-30iA Mate and R-30iB / R-30iB Mate** controller.

Change

Change

"3.1 Network configuration" was changed. Please see bold characters.

3.1 Network configuration

Please refer to the network configuration diagram above:

Change

Change

- Robot link private network should not be connected directly to Ethernet trunk line. It is possible that unexpected motion may occur if **there are** excessive numbers of collisions impacting throughput of robot link packets by FTP or other operations occurring on the Ethernet trunk line. The packets for robot link are broadcast type packets and may adversely **affect** the operation of the Ethernet Trunk line. Robot Link execution can consume a large amount of the Trunk line Ethernet capacity.
- Ethernet cable must be installed to avoid physical damage. For example, the Ethernet cable must not interfere with human operator or any other moving object in robot site.
- Please take enough countermeasures to prevent the electrical noise on Ethernet cable. Ethernet cable must not be allocated near to equipment that generates electronic noise.
- The power cord of Ethernet switch should not interfere with human operator or any moving object in robot site.
- The connection between Ethernet cable and Ethernet switch must be permanent. You should consider Ethernet cable routing and Ethernet switch installation as a permanent connection. If the connection is loose, then stable Ethernet communication is not possible. This will prevent robot synchronous motion from starting, or can cause current robot synchronous motion to stop, or prevent teaching robot positions in the synchronized slave robot program.

  This point is very important. Please be careful about this point

  ○ You can confirm Ethernet cable connection by the amber LED which is mounted near the RJ-45 connector on R-J3iB main PCB. After you have connected Ethernet cable between robot controller and Ethernet switch, please cycle power of both robot controller and Ethernet switch. If the connection between robot controller and Ethernet switch is OK then the amber LED will turn on. If you have installed Ethernet cable and the switch correctly but the LED does not turn ON, then please contact to FANUC service center and report your problem to FANUC.

  ○ Normally, Ethernet switch has LEDs to show communication status on its front surface for diagnosis. Please check this LEDs when Ethernet communication problem occurs. The switch should be installed as you can see the LEDs easily for such diagnosis.

- ~~**If emergency stop, hold, or alarm stops one robot of robot link system, and then other robots in the robot link system should be stopped together. You should design remote control signals to meet this requirement.**~~

Delete

						Title	FANUC Robot Series R-30iA/R-30iA Mate CONTROLLER Robot Link Operator's Manual Support both R-30iA and R-30iB
						Draw No.	B-82924EN/01 - 3
01	2016.4.11	T. Hannya	Initial release				
Ed.	Date	Design	Description			FANUC CORPORATION	Page 5/10
Date		2016.4.11	Design.	T. Hannya	Apprv.		

"3.2 PLC programming for robot link system for robot link robots." was all deleted.

~~3.2 PLC PROGRAMMING FOR ROBOT LINK SYSTEM FOR ROBOT LINK ROBOTS.~~

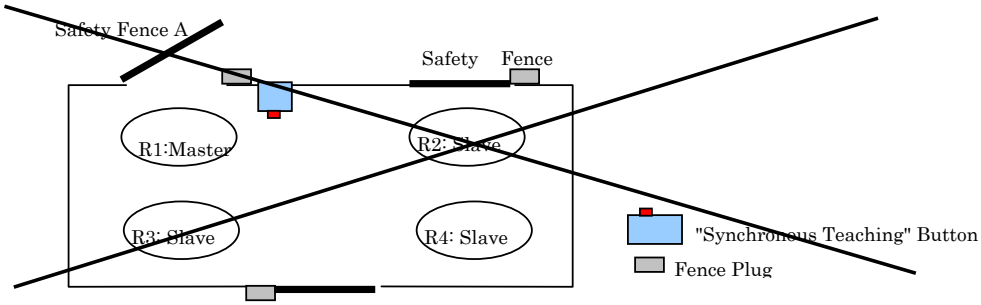
- ~~Use the "Robot link status signal" in Multi-Arm setup screen. Please refer "4-3-3 Setup status signal" in this manual. This status signal turns ON automatically when the robot is in synchronous motion.~~
- ~~If a robot in synchronous motion detects any input signal that causes emergency stop, the other robots should be stopped also as emergency stop. Please follow the next signal logic.~~
  - ~~When EMGOUT signal of one robot in robot link network is ON, if other robots' "status signal" and PROGRUN (UO3) are both ON, then input External Emergency signal to the robots until their PROGRUN output become all OFF. This check should be enabled at once after all PROGRUNs of all robots in robot link network are ON, and should be continued until the PROGRUNS are all OFF.~~
- ~~When a robot in synchronous motion detects HOLD input, the other robots should be stopped by HOLD input. Please follow the next signal logic.~~
  - ~~When PROGRUN output of a robot in robot link network is OFF, if other robots' "status signal" and PROGRUN (UO3) are both ON, then input *HOLD (UI2) to other robots until their PROGRUN output become all OFF.~~
    ~~This check should be enabled at once after all PROGRUNs of all robots in robot link network are ON, and should be continued until the PROGRUNS are all OFF.~~
- ~~When a robot detects an alarm to stop robot in synchronous motion, other robots should be stopped by emergency stop. Please follow the next signal logic.~~
  - ~~When SYSRDY (UO2) output of a robot in robot link network is OFF, if other robots' "status signal" and PROGRUN (UO3) are both ON, then input External Emergency to other robots until their PROGRUN output become all OFF.~~
    ~~This check should be enabled at once after all PROGRUNs of all robots in robot link network are ON, and should be continued until the PROGRUNS are all OFF.~~
- ~~Alarms, which may occur in synchronous motion in production phase, are mostly servo OFF alarm. So we think this signal logic does not have any side effect for daily production~~

Delete

"3.3 Cell Interface for Teaching Synchronous Motion" was all deleted.

3.3 ~~CELL INTERFACE FOR TEACHING SYNCHRONOUS MOTION~~

~~**Add a "Synchronous Teaching" button and the following signal control logic for the button to your system. This button should be located near the "safety fence A" which is close to master robot. Please see the following figure.**~~



~~**Robot link Synchronous teaching and jogging require that the master controller is in T1/T2 mode and the slave controllers are in AUTO mode. The method for supporting this is to devise a "local fence" circuit for the master robot and maintain a global fence for the slave robots. The Synchronous Teaching button makes a complete fence circuit for the slave robots by bypassing the signal around the master robot fence.**~~

~~***FENCE and *SFSPD should be controlled by PLC according to the status of safety fence A and "Synchronous Teaching" button as the following tables.**~~

~~**Safety Fence A**~~	~~**Open**~~	~~**Close**~~
~~***SFSPD(Normally ON)**~~	~~**OFF**~~	~~**ON**~~

~~**Safety Fence A**~~	~~**Open**~~		~~**Close**~~	
~~**Synchronous Teaching Button**~~	~~**ON**~~	~~**OFF**~~	~~**ON**~~	~~**OFF**~~
~~***FENCE(Normally ON)**~~	~~**ON**~~	~~**OFF**~~	~~**ON**~~	

~~**If another fence is opened, *FENCE to all the slave robot must be OFF to stop robots by FENCE alarm.**~~

~~**PLC must control the following signals when the "synchronous teaching" button is ON.**~~
~~**This is to limit that only master robot operator can control slave robots.**~~

- ~~**If CMDENBL signal of slave robot is OFF (For example, TP is disabled, Remote switch is set to local, single step enabled, Disabled to move, etc), input external emergency signal or servo disconnect signal to stop all the robot.**~~
- ~~**Even if CMDENBL of slave robot is ON, program start by external signal must be disabled. In the robot link system, regardless of the "Synchronous Teaching" button status, each robot's EMGOUT signal should be connected to the other robot's ESTOP input so that all the robots are stopped by any other robot's E-STOP or deadman release event.**~~

Delete

				Title	FANUC Robot Series R-30iA/R-30iA Mate CONTROLLER Robot Link Operator's Manual Support both R-30iA and R-30iB
				Draw No.	B-82924EN/01 - 3
01	2016.4.11	T. Hannya	Initial release		
Ed.	Date	Design	Description	FANUC CORPORATION	Page 7/10
Date	2016.4.11	Design.	T. Hannya	Apprv.	

"3.4 Teaching procedure for Robot Link programs" was modified.

3.4 TEACHING PROCEDURE FOR ROBOT LINK PROGRAMS

Following is the procedure for teaching the robot link system. This is the minimal teaching sequence for single point Slave robot link slave Sub program. This information will be repeated in more detail in a later section. An additional slave Sub program type that supports multiple slave program positions is also covered.

Add

- **Set master robot T1 or T2 mode and slave robot AUTO mode.**
- **Operator of master robot must be outside of safety fence and close safety fence. Unless fence is not closed, slave robot doesn't move.**

> ⚠ **WARNING**
> **Operator must be outside of the safety fence when teaching. It is danger in the fence because slave robot is AUTO mode.**

- Master robot operator presses the reset button on TP to reset master robot's alarm status.
- To teach positions on the salve robots, the master robot must transmit its position to the slave robots. This is done in the Manual Function menu by selecting Robot Link, then set a link pattern, and finally press the "Master" soft key on the teach pendant. This operation is described later in this manual. This procedure is also used to initiate Robot Link jogging. In the robot link manual function screen, if master robot status is changed to "Master (Manual)", then master robot operator can perform Robot Link jogging.
  - ○ If slave robots are in alarm status, by the "MASTER" button operation in master robot manual function screen, slave robots try to reset its alarm status. This case, master robot status in the manual function screen is displayed as "Link incomplete" at first. So please re-try the "MASTER" button. If the status is changed to "Master (Manual)", then Robot Link jog becomes available.
  - ○ If slave robot cannot reset the alarm status by some alarm cause, master robot's status is kept to be "Link incomplete". In this case, please remove alarm cause from slave robot and retry.

~~- The master robot operator turns OFF the "Synchronous Teaching" button after teaching robot link program.~~

> ~~⚠ WARNING~~
> ~~- "Synchronous Teaching" button should be ON only in robot link teaching operation.~~
> ~~- When the master robot operator is teaching a robot link program, the slave robot operator must be outside of the safety fence~~.

~~- RIA specification~~

~~In case of RIA specification, the following steps must be added to the above operation.~~

~~✓ When slave robot operator gets out of safety fence for robot link teaching, the slave robot must be set to AUTO mode.~~

~~✓ In RIA specification, deadman release event is not passed to EMGOUT signal. With deadman SW monitor (future optional functionality), please input External emergency signal servo disconnect signal to stop another robot from deadman switch.~~

Delete

						Title	FANUC Robot Series R-30iA/R-30iA Mate CONTROLLER Robot Link Operator's Manual Support both R-30iA and R-30iB
						Draw No.	B-82924EN/01 - 3
01	2016.4.11	T. Hannya	Initial release				
Ed.	Date	Design	Description			FANUC CORPORATION	Page 8/10
Date		2016.4.11	Design.	T. Hannya	Apprv.		

“3.5.5 ROS IP CONFIGURATION FILE:” was changed. Please see bold characters.

3.5.5 RIPE SETUP:

In R-30iA, RIPE is setup by creating ROSIPCFG.XML and loading it into FRS:.
In R-30iB, RIPE setup menu can be used.

3.5.5.1 Setup RIPE for R-30iA

The data for inter-controller setup is in ROSIPCFG.XML. This file is loaded into “FRS:” memory on the controller. It indicates the “Robot Ring” for MASH control and also defines the “iPendant Ring” to support iPendant remote logon to a remote robot controller. There may be future functions added to this file. Since this file relies on IP and Name information of the robots, it must be created for each robot ring. Following is an example ROSIPCFG.XML.

```
<?xml version="1.0" ?>
<!--
The order implies the "index" in the ring
  -->
<ROSIPCFG>
  <ROBOTRING count="2" timeslot="100">
    <MEMBER name="robhand" ipadd="190.1.5.17"/>
    <MEMBER name="robspot" ipadd="190.1.5.18"/>
  </ROBOTRING>
</ROSIPCFG>
```

All robots in the robot ring have a copy of this file installed on them.

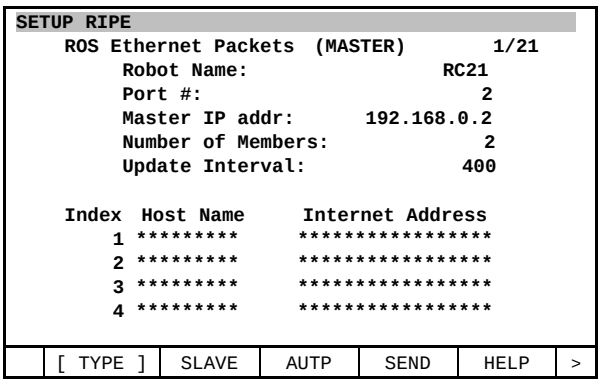
3.5.5.2 Setup RIPE for R-30iB

RIPE uses a “Master” controller which serves to coordinate the RIPE network ring, and one or more “Slave” controllers which share the RIPE ring.
RIPE can be configured automatically using the below procedure. RIPE configuration should be done after the host name, Port #2 IP address, and Port #2 subnet mask are configured in TCP/IP menu of Host Comm.
For details of RIPE setup and operations, please refer to APPENDIX D, “ROS INTERFACE PACKETS OVER ETHERNET (RIPE)” in the Ethernet Function OPERATOR’S MANUAL (B-82974EN).

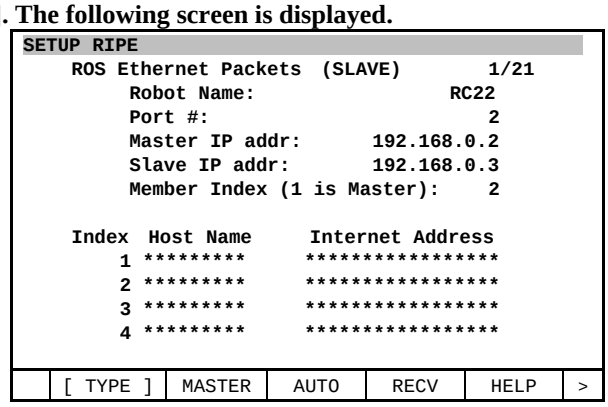
RIPE setup procedure for R-30iB

1. **Press MENU key.**
2. **Select [6 SETUP]**
3. **Select [Host Comm]. The master Host Comm menu will be displayed.**
4. **Move the cursor to RIPE and press F3 [DETAIL] to enter the RIPE setup menu. SETUP RIPE display for MASTER of RIPE is displayed. If Master IP addr is *, return Host Comm menu and select RIPE again.**

Totally corrected



5. Press F2[SLAVE]. The following screen is displayed.



6. Please confirm that IP address of each controller is continuous number. The controller set the top IP address of continuous number become MASTER for RIPE by following setup and the other controllers become SLAVE for RIPE.

For example, in a case of 3.1.2.1, the controller set 192.168.0.2 become MASTER.

7. Set up the Controller as SLAVE by following procedure on "ROS Ethernet Packets (SLAVE)" menu.

7.1. Set IP address of MASTER controller to "Master IP addr:" Select the controller set the f IP address of continuous number as MASTER.

7.2 Set "Member Index. Input the IP address order of this robot controller from the top. According to this order setting, [Slave IP addr] is set automatically. Verify that the displayed IP address and the IP address which you assigned to this controller are same.

7.3. After finishing the above procedure, press F3 AUTO.

7.4. You will be asked whether this controller can cycle the power after receiving data, then press F3 YES.

8. Set up the Controller as MASTER by following procedure on "ROS Ethernet Packets (MASTER)" menu.

8.1. Set up "Port #". Input the port number is used for RIPE.

8.2. Set up "Number of Members". Input the number of controllers which join the ring.

8.3. Set the Update Interval. 400ms is acceptable.

8.4. Press F3 AUTO on the MASTER controller.

8.5. When "Put all SLAVES in AUTO mode" is displayed, press F4[CONTINUE].

8.6. "When Cycle power for setting to take effect?" is displayed, select YES to automatically cycle power and install RIPE configuration on all controllers in RIPE ring.

Modified description to FANUC Robot Series
R-30*i*A/R-30*i*A Mate/R-30*i*B/R-30*i*B Mate CONTROLLER Robot Link Operator's Manual

1.Type of applied technical documents

Name	FANUC Robot Series R-30*i*A/R-30*i*A Mate/R-30*i*B/R-30*i*B Mate CONTROLLER Robot Link Operator's Manual
Spec.No./Ed.	B-82924EN/01

2.Summary of Change

Group	Name/Outline	New, Add, Correct, Delete	Applicable Date
Basic			
Optional Function	Description has been modified	Correct	Immediately
Unit			
Maintenance Parts			
Notice			
Correction			
Another			

Ed.	Date	Design	Description
Date	2016.09.30	Desig. Matsushima	Check / Apprv.

Title	Modified description to FANUC Robot Series R-30iA/R-30iA Mate/R-30iB/R-30iB Mate CONTROLLER Robot Link Operator's Manual
Draw No.	B-82924EN/01-4
FANUC CORPORATION	1/3

The following description at "5.3 CALIBRATION OF CALIBRATION DATA" is modified.

2. Please transport the TP programs that are recorded three reference points to PC via Memory card or USB Memory. However, you should set a name of each calibration program within 8 characters. The calibration tool does not support long file name which is longer than 8 characters.

⇩

2. Please transport the TP programs that are recorded three reference points to PC via Memory card or USB Memory.

NOTE
You should set a name of each calibration program and each registered macro name and program name used as macro regardless of the possibility of using macros in the calibration program within 8 characters. The calibration tool does not support long file name which is longer than 8 characters.

The following description at "7.1 PROGRAMMING FOR MASTER PROGRAM" is modified.

4. Set each item.

Item	Contents	Range
Synchronization ID	Set ID for slave program that pairs this master program. If the pairing slave program is not created set temporary value. The synchronous ID is used in order to avoid that the unexpected programs synchronize with this master program in case that there are some synchronous motions.	1 – 99999
Link Pattern No.	Set link pattern number. Set the number for the used link pattern beforehand.	$RK_SETUP.$NUM_PTN Don't change these system variables.

⇩

4. Set each item.

Item	Contents	~~Range~~
Synchronization ID	Set ID for slave program that pairs this master program. If the pairing slave program is not created set temporary value. The synchronous ID is used in order to avoid that the unexpected programs synchronize with this master program in case that there are some synchronous motions.	1 to 99999
Link Pattern No.	Set link pattern number. Set the number for the used link pattern beforehand.	1 to $RK_SETUP.$NUM_PTN

Modified

$RK_SETUP.$NUM_PTN is the maximum number of link patterns. The default value is 1. Please change the value from 1 to 9 for your system.

Addition

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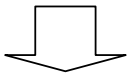
The following description at "7.2 PROGRAMMING FOR SLAVE PROGRAM" is modified.

4. Set each item.

Item	Contents	Range
Synchronization ID	Set ID for slave program that pairs this master program. If the pairing slave program is not created set temporary value. The synchronous ID is used in order to avoid that the unexpected programs synchronize with this master program in case that there are some synchronous motions.	1 – 99999
Slave Group	Set the motion group for synchronous motion. Set cursor to this item and press [F4] (1).	Only the motion group set in this program can be set.
Master No.	Set the master robot number. Set the number for the master robot beforehand.	1 - $RK_SETUP.$NUM_MST Don't change these system variables.
Master tool No.	Set the tool frame number used in the program of the master robot. *** At present, this function has not been supported yet.** **Don't set the value except 0.**	0-5



4. Set each item.

Item	Contents	Range
Synchronization ID	Set ID for slave program that pairs this master program. If the pairing slave program is not created set temporary value. The synchronous ID is used in order to avoid that the unexpected programs synchronize with this master program in case that there are some synchronous motions.	1 to 99999
Slave Group	Set the motion group for synchronous motion. Set cursor to this item and press [F4] (1).	Only the motion group set in this program can be set.
Master No.	Set the master robot number. Set the number for the master robot beforehand.	1 to $RK_SETUP.$NUM_MST
Master tool No.	Set the tool frame number used in the program of the master robot. *** At present, this function has not been supported yet.** **Don't set the value except 0.**	0

Modified

$RK_SETUP.$NUM_MST is the maximum number of master robots. The default value is 1. Please change the value from 1 to 7 for your system.

Addition

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