Warning

All installation work must be performed by a qualified installer and must comply with applicable laws and regulations.

HD HYUNDAI ROBOTICS

# Hi5a Controller Function Manual

## Pick-it Application

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## Configuration of the manual

This manual consists of five chapters and an appendix.

Chapter 1 gives an overview of the configuration of an application system that uses a robot and the Pick-it equipment. This chapter briefly describes how to interoperate between the robot and the Pick-it equipment application interface as well as the overall operation flow.

Chapter 2 describes the procedures and setting methods regarding the use of the robot and the Pick-it equipment. To carry out a work using the robot and Pick-it equipment, it is necessary to set individual systems before interoperating them. This chapter contains detailed procedures and additional descriptions.

Chapter 3 describes the HR-BASIC commands for the Pick-it interface. The dedicated HR-BASIC for the Pick-it equipment consists of commands and variables and provides relevant methods and examples of usage.

Chapter 4 describes how to carry out calibration and picking works through interoperation between the robot and Pick-it equipment. This chapter describes specifically how to configure the robot and Pick-it equipment to carry out calibration and picking works and how to write a JOB file to carry out work.

Chapter 5 describes the precautions that users should take when configuring a system and carrying out works using the robot of Hyundai Robotics and Pick-it equipment. This chapter also provides additional information.

The appendix contains examples of JOB files of the calibration and picking works for which the robot of Hyundai Robotics and Pick-it equipment are to be used. By applying them, users can write JOB files for various purposes.

# 1

# Introduction of the Pick-it Equipment

## 1.1. Introduction of Functions

The Pick-it equipment is robot application equipment that provides position and posture to pick a workpiece by processing 3D pictures. The equipment uses a 3D camera to take a picture of workpieces, identifies individual workpieces in the taken picture using a picture processing algorithm, and calculates the 3D position and posture information of individual workpieces at the same time. The equipment also transfers the calculated workpiece to pose information to the robot. Then, the robot can pick and move the workpiece based on the size and posture information transferred to it. In addition, the equipment can be used to load, align, and allocate workpieces. For more details of the applicable functions of the Pick-it equipment, please refer to the web page or manuals of Pick-it, the company.


**Figure 1-1 Pick-it 3D camera**

### 1.1.1. Configuration of the Pick-it equipment

The Pick-it equipment consists of a 3D camera, picture processing software, a server equipped with picture processing software, a calibration plate, and accessories. Please contact the company for more details about the product groups as well as systems and specifications.

**Figure 1-2 Pick-it picture processing equipment**

### 1.1.2. Configuration of the Pick-it software

The Pick-it software is installed in the server and mainly divided into the picture processing part and the Chrome user interface. The picture processing part is an internal operation process that the user cannot access. Only the Chrome user part interface can be accessed by the user. Through the Chrome user interface, the user can check the picture taken by the camera, set the working environment and the type of workpiece, and others.

# 1.2. Overview of Interoperation with the Robot

## 1.2.1. Overview of interoperation between the robot and Pick-it equipment

The robot and Pick-it equipment are interoperating with each other to perform works. For this, functional roles and operational sequences between the robot and equipment are defined to carry out works smoothly.

In terms of functions to perform works during the interoperation between the robot and Pick-it equipment, the robot acts as the master. The Pick-it equipment acts as the slave, in terms of functions, and reacts passively to the commands from the robot. In terms of communication, the robot acts as the client that sends a command to the Pick-it equipment whenever there is a desired function. The Pick-it equipment acts as a server that prepares to receive a command from the robot. When receiving a command from the robot, the Pick-it equipment processes the command. Please note that the robot and Pick-it equipment will respectively play different roles depending on the division of their roles in functions and communication.

The Pick-it equipment waits to receive a command from the robot, and when receiving a command, it processes the command and sends the result to the robot. In other words, the equipment operates only in response to the robot control commands that are executed by the user. It does not periodically send or receive system variable or commands in the background independent of the robot's commands. Such a simple operation method allows users to design the work intuitively and simply.



## 1.2.2. Necessary procedures for interoperation

The procedures shown below should be followed to carry out works by interoperating the robot and Pick-it equipment.

- Physical installation of the robot and Pick-it equipment
- Setting of the robot control environment
- Setting of the Pick-it control environment
- Ethernet communication connection between the robot and Pick-it equipment (using UDP2TCP converter)
- Calibration of the Pick-it equipment
- Writing JOB files for the robot operation involving the interoperation with the Pick-it equipment
- Performing works involving the interoperation between the robot and Pick-it equipment

The following chapters and sections in this manual contain detailed descriptions for each procedure. (This manual focuses on the interface between the robot of Hyundai Robotics and Pick-it equipment and does not cover the descriptions for the installation of the robot and Pick-it equipment. Please refer to relevant installation documents for the installation of the robot and Pick-it equipment.)

### 1.2.3. Common operation flow

Figure 1-3 describes the roles and operation flow between the robot and Pick-it equipment. The flow of all operations between the robot and Pick-it equipment is basically the same as that shown in Figure 1-3. In the figure, the vertical lines between the robot and Pick-it equipment indicate the timeline, meaning that time passes from top to bottom. There are two vertical lines. The left one shows the time and operation of the robot, and the right one shows the time and operation of the Pick-it equipment. The horizontal lines between the two vertical lines indicate the command and variable to be exchanged between the robot and Pick-it equipment transferred in the direction indicated by the arrow.

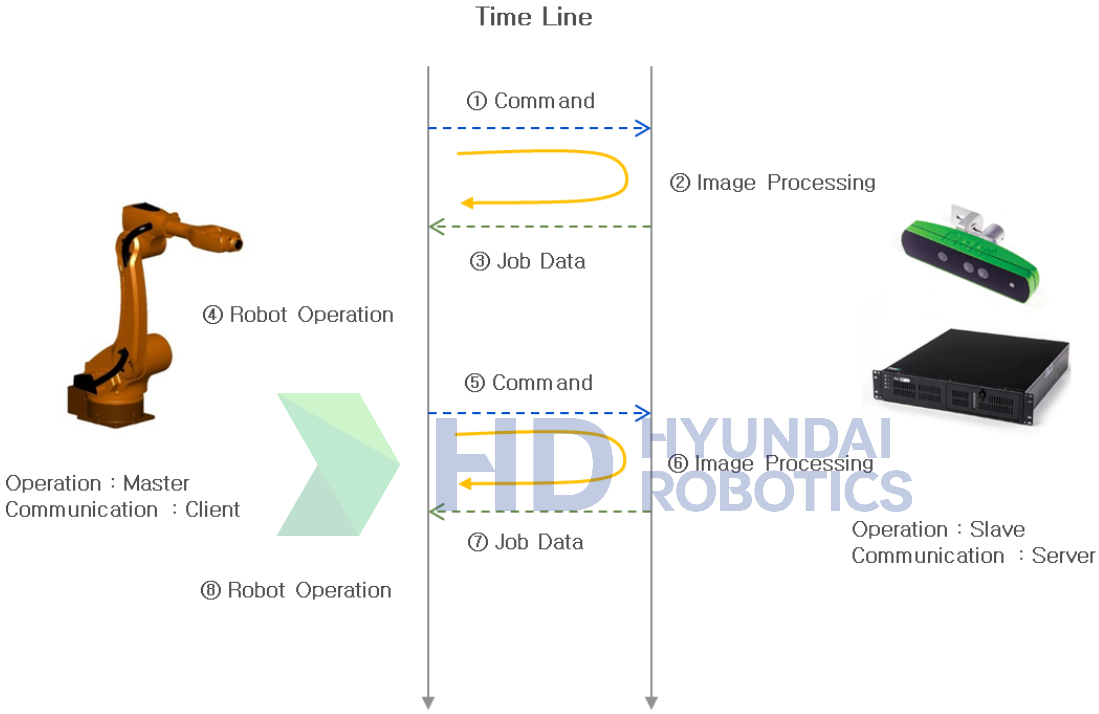


**Figure 1-3 Flow of operations between the robot and Pick-equipment**

The basic operation sequence between robot and pick-it equipment is as follows.

- When there is no work, both the robot and Pick-it equipment are all in waiting mode.
- When work is generated, the robot sends a command to the Pick-it equipment.
- The Pick-it equipment waits for a command from the robot, and when receiving a command, processes the relevant command.
- In between, the robot waits to receive the command processing result from the Pick-it equipment.
- When receiving the processing result from the Pick-it equipment, the robot performs the work starting from this moment.
- When the work is finished, the robot sends a command again to the Pick-it equipment and repeats the above process.

The robot and Pick-it equipment are interoperating according to the above process. The commands and variables to be exchanged will vary only according to the commands and works, while the flow is the same. Detailed descriptions of the actual process of sending a command and receiving variables are covered in Chapters 3 and 4.

## 1.2.4. Support for communication

Currently, the Pick-it equipment supports Ethernet TCP communication, and the Hi5a controller and the robot of Hyundai robotics support Ethernet UDP communication, respectively. Therefore, for the robot and Pick-it equipment to interoperate, separate communication equipment is needed to perform the conversion in the middle. In other words, it is necessary to have separate equipment that can convert TCP variable into UDP variable and vice versa between TCP and UDP communications supported by the robot and Pick-it equipment, respectively.

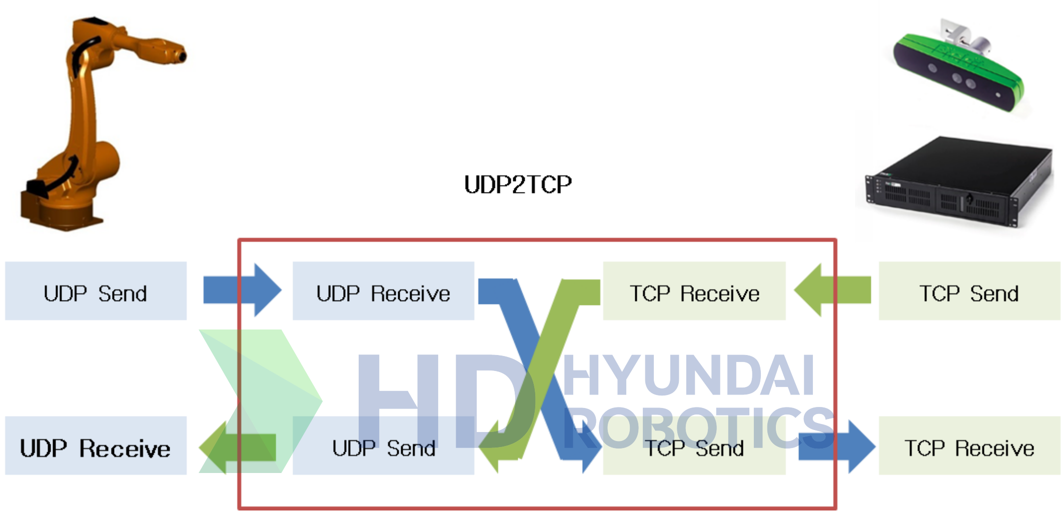


**Figure 1-4 Communication conversion between the robot of Hyundai Robotics and Pick-it equipment**

To solve the problem of using different communication protocols between the robot and Pick-it equipment, Hyundai Robotics provides UDP2TCP software and hardware to convert UDP variable into TCP variable. The relevant equipment will convert the communication protocols between Hyundai Robotics and Pick-it, making it possible to perform smooth communication between two different protocols used by the robot and Pick-it equipment.

The UDP2TCP converter provided by Hyundai Robotics is universal equipment, meaning that it is not dedicated to our robots and can be used for other communication equipment as well. However, as the UDP2TCP converter is mainly designed to support the communication between the robot and Pick-it equipment, it cannot be used when communication is performed at a frequency of 1 kHz or higher. If there is another universal communication equipment that can perform protocol conversion between UDP and TCP, it can be used without affecting the operation. Refer to Chapter 2 for details.

# 2

# Configuration and Setting of the System

## 2.1. Configuration and Setting of the System

The robot and Pick-it equipment must be installed first to perform works using them. The installation includes physical installation of the robot and Pick-it equipment as well as the configuration of communication system. This manual focuses on describing the communication system configuration for the interface between the robot and Pick-it equipment.

### 2.1.1. Overview of equipment installation

The basic equipment includes the robot, Pick-it equipment, and a PC for setting the Pick-it equipment. The robot and Pick-it equipment send and receive commands and variable via Ethernet communication. However, the Hi5a controller supports the UDP protocol only, and the Pick-it equipment supports the TCP protocol only. To solve this problem, we provide software and a converter for UDP2TCP protocol conversion. To connect all the equipment mentioned above, users need a UDP2TCP converter and an Ethernet switch in addition to the robot and Pick-it equipment. Figure 2-1 shows the configuration of all equipment connected via Ethernet communication.

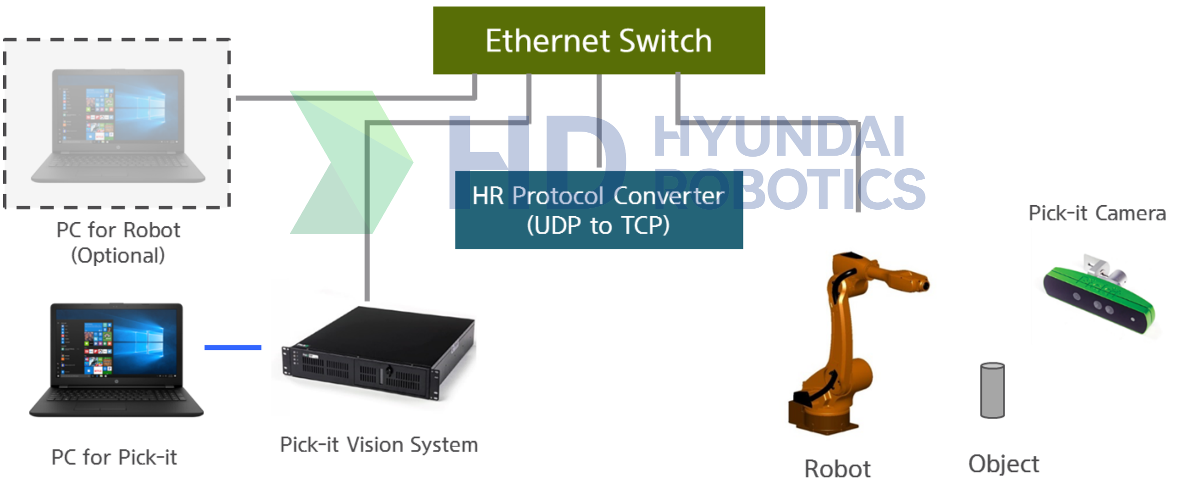


**Figure 2-1 System configuration for interoperation between the robot and Pick-it equipment**

# 2.2. Installation of the Pick-it Equipment

## 2.2.1. Installation of the Pick-it camera and server

The Pick-it equipment largely consists of a 3D camera and a server equipped with algorithm processing software. The server should be installed in an appropriate space for convenience. However, the camera should be installed considering the characteristics of the work, the size and type of the workpiece, and the working space.

There are mainly two methods of installing the camera, as shown below.

- Installing a separate mount structure and installing the camera onto it
- Installing the camera onto the robot arm

Depending on the camera installation position and method, the field of view can be changed, and the operation of the Pick-it equipment can be determined. The closer the camera is to the workpiece, the better the picture will be. However, to obtain the 3D picture variable, the camera should be away from the workpiece at least at a certain proper distance. The proper distance varies depending on the model of the Pick-it equipment and is influenced by the form of the workpiece and by the working space. Therefore, refer to the Pick-it Equipment Installation Manual and consult with the professional installers before progressing the installation.

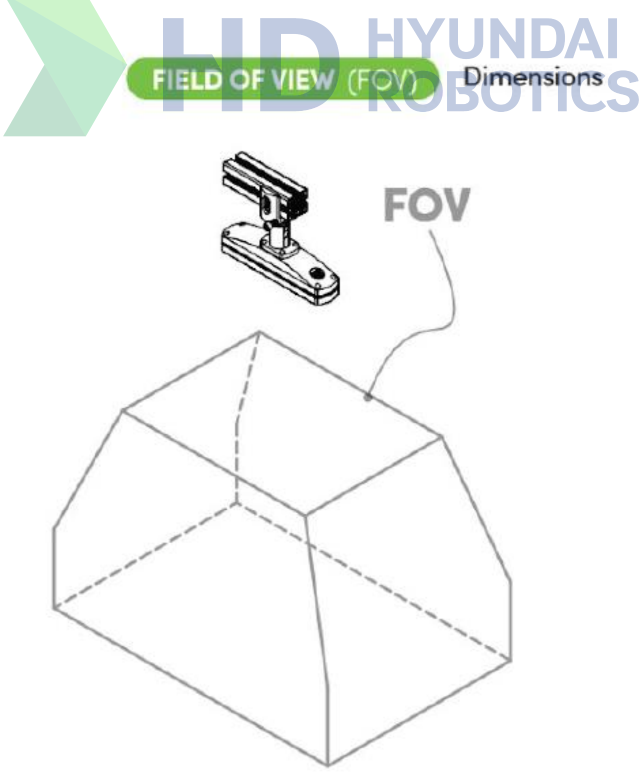




**Figure 2-1 Field of view (FOV)**

## 2.2.2. Setting of the Pick-it equipment

To carry out works using the Pick-it equipment, it is required to access the Pick-it equipment setting screen via the Chrome web browser. The first thing to do after the access is to select the Region of Interest (ROI) tab, and then, set the region of the screen where the workpiece will be placed. The difference between FOV and ROI is that the FOV is the entire region seen by the camera, and the ROI is the selected portion of the FOV that will go through picture processing. Therefore, the ROI must be equal to or smaller than the FOV.

In the Detection and Picking tabs, set the detection and picking method, respectively. The Detection Tab is for performing settings related to the method of detecting a workpiece, the Picking Tab is for setting the picking method, and the Calibration Tab is for performing calibration. Lastly, after all the settings are completed, you can store them as a Setup File and a Product File using the Configuration Tab. (Refer to the Pick-it Equipment Manual for detailed setting methods.)

## 2.3. Installation of the Robot

### 2.3.1. Installation of the robot

Please consult our experts for the installation of the robot of Hyundai Robotics. There is nothing to be careful about when installing the robot to use the Pick-it equipment. If there is a robot already installed, you can use the robot without moving it. Please contact Hyundai Robotics for consultation and questions about the system construction.

### 2.3.2. Installation posture of the robot

There is no limit to the installation posture of the robot to use the Pick-it equipment. However, this manual provides descriptions based on six degrees of freedom robot installed on the ground surface in correct posture. When installing the robot in a different posture, be cautious about the direction of the robot coordinate and the base coordinate in line with the installation posture. Contact the technical support for questions about the installation posture of the robot.

### 2.3.3. Setting of the robot

To use the Pick-it interface, the robot controller should have software supplemented with the Pick-it interface and a statement processing function. Please check the software version of the currently installed controller considering that the relevant function is supported only in a software version after a specific version. Contact Hyundai Robotics for a version update of the TP and controller.



The controller with the software that supports the Pick-it interface is supplemented with the following functions.

- Pick-it interface applied robot commands and variables
- Internal interface function processing between the robot and Pick-it equipment

The software that supports the Pick-it equipment should be installed to use the commands related to the Pick-it equipment and interpret the robot languages. If a controller does not have the software that supports the statement related to the Pick-it interface, an error will be generated when trying to copy a JOB file that contains a Pick-it statement from a PC to the controller, and the copying process will fail.

To interoperate the robot controller equipped with the software that supports the Pick-it interface with the Pick-it equipment, the user just needs to connect the Ethernet cable and set the Ethernet address only. For this reason, the TP does not provide a separate setting page on its screen.

## 2.4. Installation of the Communication System

### 2.4.1. Overview of the installation of the communication system

An Ethernet communication connection is required for the robot and Pick-it equipment to interoperate. For the Ethernet communication connection, the controller of Hyundai Robotics provides one Ethernet port, while the Pick-it equipment provides two Ethernet ports. The UDP2TCP conversion equipment should be used between the robot controller and the Pick-it equipment for protocol conversion. The complete Ethernet connection among the robot, Pick-it equipment, and the UDP2TCP conversion equipment is shown in Figure 2-1. There is a separate PC for monitoring the robot controller, updating the SW version, and downloading the JOB file. However, it is an option for convenience and does not have to be used when the robot is interfacing with the Pick-it equipment.

### 2.4.2. Pick-it communication port

There are two Ethernet ports on the Pick-it server. One is to connect to the robot controller, and the other is to connect to the PC to control the Pick-it server. If you take a closer look at the port sockets, you can see a guide mark for connecting them to the robot and PC. Check them well when connecting to the robot and PC.

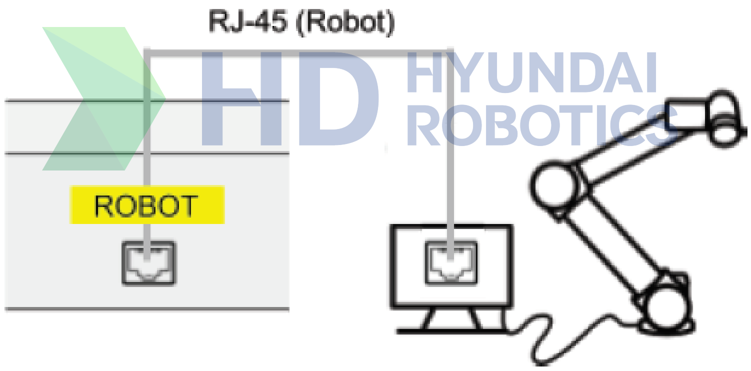


**Figure 2-2 Connecting the Ethernet port for the robot**

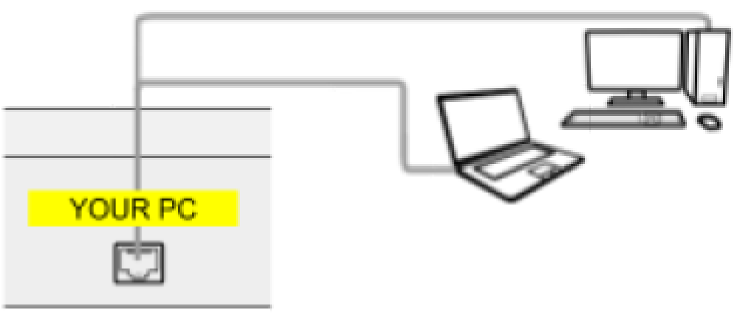


**Figure 2-3 Connecting the Ethernet port for the PC**

The Pick-it equipment provides two Ethernet ports, as described above. If you use a robot capable of TCP communication, you can directly connect the robot to the PC without using an Ethernet switch or router separately. Figure 2-5 below shows an example of connecting a robot that supports the TCP to the Pick-it equipment. The PC port can be directly connected to the PC using an Ethernet cable, and the robot port can also be connected directly to the robot controller using an Ethernet cable. Connections can be made using the Ethernet cable provided by Pick-it or a general Ethernet cable. When the TCP communication is used, the entire communication system can be simply configured.


**Figure 2-4 Ethernet connection to the Pick-it equipment through TCP**



Since the Hi5a controller of Hyundai Robotics supports only UDP communication, it cannot be configured, as shown above. It is required to connect it through an Ethernet switch together with a UDP2TCP converter, as shown in Figure 2-1.

For the Pick-it equipment to communicate with the robot, it is required to set the Ethernet IP address and port number of the Pick-it equipment after connecting the Ethernet cable. You can set the IP address and port number of the Pick-it equipment on the Chrome screen by setting them to the values shown in Table 2-1. The precaution to take in this process is that this address and number are for the Ethernet port for the interoperation with the robot and should not be confused with the one for the interoperation with the PC.

**Table 2-1 Pick-it IP address and port number**

| | |
|---|---|
| Pick-it TCP IP address | 192.168.1.12 |
| Pick-it TCP port number | 5001 |

## 2.4.3. Communication port of the robot of Hyundai Robotics

The Hi5a controller of Hyundai Robotics only supports UDP Ethernet communication. For the Ethernet connection to the robot controller, it is required to connect the connector at one end of the Ethernet cable to the robot controller Ethernet socket and the other one to the Ethernet socket of the Ethernet switch.

After the Ethernet cable is connected, the Ethernet IP address and subnet mask should be set for the robot to perform Ethernet communication. The Ethernet address of the controller itself will be basically set, as shown below, after the robot is installed. Refer to Figure 2-6 for the Ethernet environment setting screen of the TP. To return to the basic setting, make the settings using the numbers, as shown in Table 2-2. It is recommended that you should use, if possible, the basic settings without changing the basic values of the IP address, subnet mask, and the gateway.

**Table 2-2 Hi5a controller Ethernet setting**

| | |
|---|---|
| Controller IP address | 192.168.1.254 (Basic address) |
| Controller subnet mask | 255.255.255.0 |
| Controller gateway | 192.168.1.1 |

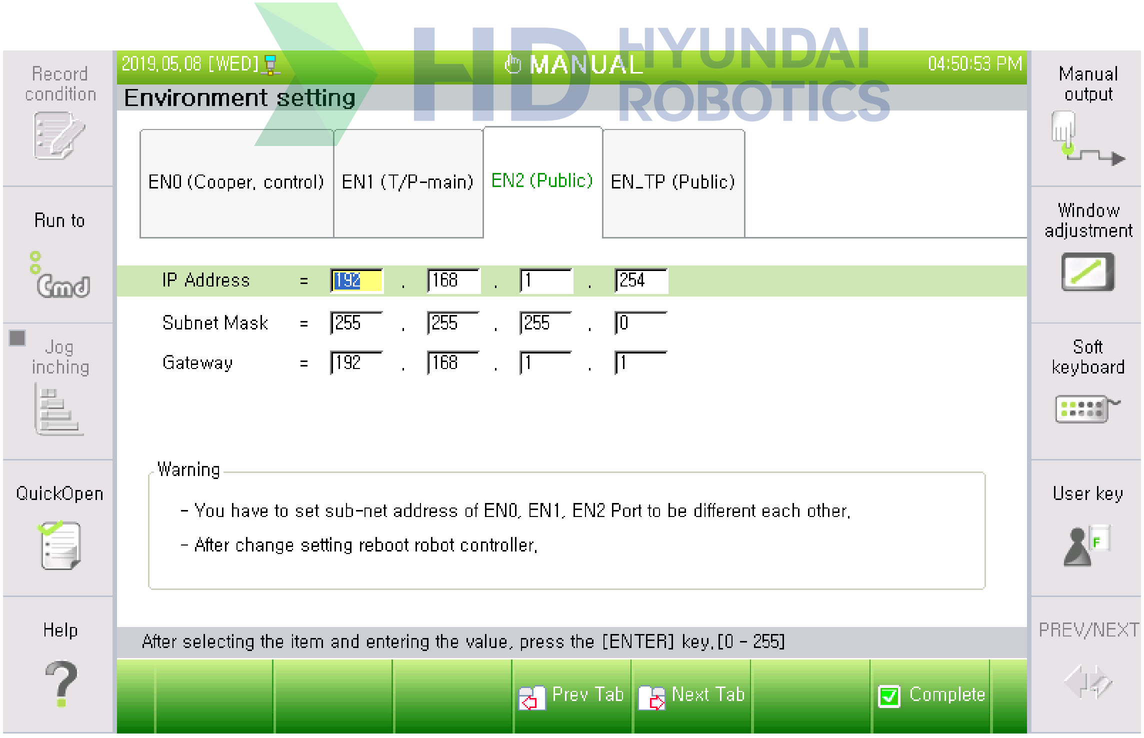


**Figure 2-5 TP Ethernet setting screen**

The Ethernet IP address of the controller itself can be freely changed between [192.168.1.0] and [192.168.1.255] by the user. However, the IP address you want to change should not overlap with the address used by EN_TP (Universal) [192.168.1.25] (Basic), UDP2TCP converter [192.168.1.11], and the Pick-it equipment [192.168.1.12]. For more information, the [192.168.XXX.XXX] IP address band is a special address band used as an internal private IP address.

For the robot to carry out works by interoperating with the Pick-it equipment, the Ethernet IP address and port number of the UDP2TCP converter should be inputted into the Ethernet statement that is used to set the receiving part in a way that the Ethernet variable in the JOB file should go through the UDP2TCP converter without going directly to the Pick-it equipment. In this way, the robot controller will send the variable to the UPD2TCP converter, and the converter will receive the variable and send them to the Pick-it equipment. Refer to Table 2-3 for the Ethernet IP address and port number of the receiving part (UDP2TCP converter) to be set in the JOB file.

The address and port number of the UDP2TCP converter are fixed, and their settings cannot be changed by the user. The settings of the Ethernet IP address and port number between the robot controller and UDP2TCP converter are described with more detail in the examples of JOB files in Chapter 4.

**Table 2-3 Ethernet IP address and port number of UDP2TCP converter**

| | |
|---|---|
| UDP2TCP IP address | 192.168.1.11 |
| UDP2TCP UDP port number (RPORT) | 5001 |
| Controller UDP port number (LPORT) | 5001 |

### 2.4.4. UDP2TCP converter

As mentioned above, the Hi5a controller of the Hyundai robot supports the UDP, and the Pick-it equipment supports the TCP. To solve this problem, it is required to use the UDP2TCP converter. The function of the UDP2TCP converter is to combine “Receiving via UDP / Sending via TCP” and “Receiving via TCP/ Sending via UDP” by simultaneously realizing both the UDP and TCP communication functions.

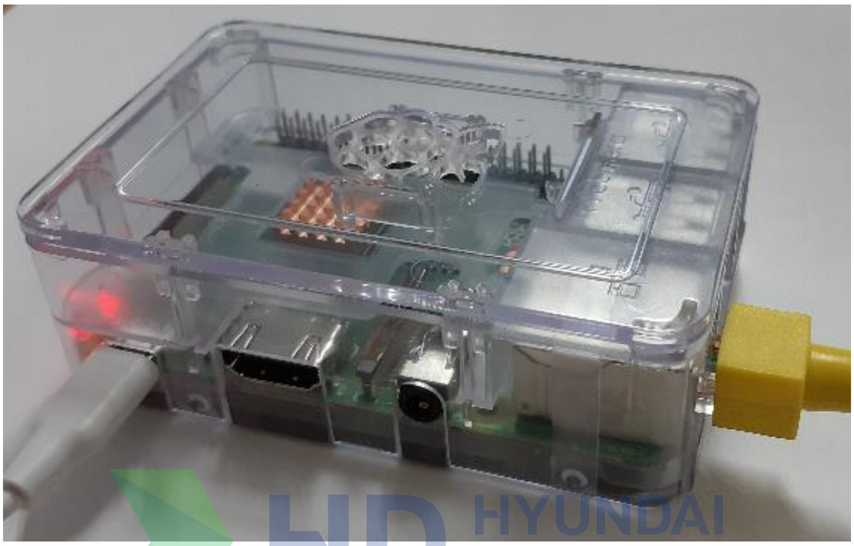

Figure 2-6 UDP2TCP converter



The UDP2TCP converter has one Ethernet port that needs to be connected to the Ethernet switch using the Ethernet cable. Then, everything is set. There is no need to operate the UDP2TCP converter separately because it will start to operate automatically when it is powered and booted up simultaneously. Currently, the IP address and TCP port used by the UDP2TCP converter are fixed to the values shown in Table 2-2. Users do not need to change the IP address or port number of the UDP2TCP converter. Instead, users just need to perform the setting in a way to ensure that the robot JOB file sends and receives variable via the fixed IP address and port number. The TCP port number of the UDP2TCP converter is fixed to “5001” to be compatible with the Pick-it equipment, and the UDP port number is also fixed to “5001.”

**Table 2-4 UDP2TCP converter TCP and UDP setting**

| | |
|---|---|
| UDP2TCP IP address (Fixed) | 192.168.1.11 |
| TCP port number (Fixed) | 5001 |
| UDP port number (Fixed) | 5001 |

In other words, when sending variable from the robot via UDP, the address of the destination should be set to “192.168.1.11,” and the port number should be set to “5001.” On the Pick-it chrome setup screen, if the IP address for the robot to access is set to “192.168.1.12” and the port number is set to “5001,” then the UDP2TCP converter will convert and transfer the variable between the robot and Pick-equipment.

## 2.4.5. Connection of the Ethernet switch

An Ethernet switch or router is needed to connect the robot controller, Pick-it equipment, and the UDP2TCP converter. A brief definition of an Ethernet switch and a router is shown in Table 5-2.

**Table 2-5 Definition of an Ethernet switch and router**

| | |
|---|---|
| **Switch** | Equipment that connects Ethernet systems and is capable of sending and receiving variable between systems connected within a small sized network in general |
| **Router** | Equipment that works as a switch and is capable of sending and receiving long-distance variable with an external network |

As equipment technology has progressed, the functional boundary between network equipment is blurred, and the terms are mixed. As a result, the definition of the equipment is not clear. You can think that the sharers generally used by people are similar to the routers in their functions. You can also think that a switch can be used alone to build a small private network that has no connection with an external network or can be connected to the router to expand the port when the ports of the router are not sufficient. For a more detailed description, refer to the descriptions for specialized networks.

Robots, Pick-it equipment, and UDP2TCP converters can communicate when they are connected to a switch or router socket through an Ethernet cable. Please note that when using a switch or router, do not connect to an external Internet. Instead, use it only for a local network. If you look at the figure of the router's ports, there is a separate port for connecting to an external network (Internet). Do not connect the robot, Pick-it equipment, or the UDP2TCP converter to this port.

When it comes to the method of connecting the robot controller, Pick-it equipment, and the UDP2TCP converter to the switch, connect them to any of the empty ports of the Ethernet switch through an Ethernet cable in any order, and supply the power. Then, the operation will be initiated immediately. Refer to Figure 2-1.

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# 3

# Commands and Variables

## 3.1. Pick-it Commands

Hyundai Robotics provides dedicated commands and variables for the interoperation with the Pick-it equipment. Using these Commands and variables, users can send commands to the Pick-it equipment to control it or obtain pose information for picking workpieces. The Pick-it Commands and variables are basically in the type of member function and member variable (in the type of PICKIT.OOO). This chapter provides descriptions of the Pick-it dedicated Commands and variables as well as examples of their use.

### 3.1.1. PICKIT.CFG

| | | | |
|---|---|---|---|
| **Description** | A statement that sends a Setup Number and a Product Number for setting<br>This statement has two parameters: SETUP and PROD (Product).<br>The Pick-it equipment carries out the operation of loading the stored setting (Configure) corresponding to the Setup Number and Product Number.<br>The Setup Number and Prod Number to be set should be set and stored in the Pick-it equipment in advance. | | |
| **Syntax** | • PICKIT.CFG SETUP=<Setup Number>,PROD=<Product Number> | | |
| **Parameter** | Setup Number | The work setting number stored in the Pick-it equipment | 1~ |
| | Product Number | The workpiece number stored in the Pick-it equipment | 1~ |
| **Example of usage** | • PICKIT.CFG SETUP=1, PROD=2<br>• (Commands the Pick-it equipment to set 1 as the Setup Number and 2 as the Product Number) | | |
| **Detailed description** | • PICKIT.CFG is a statement corresponding to C_PICKIT_CONFIGURE.<br>• For the Pick-it equipment to carry out works, it is required to designate the work-related settings as well as the type of the workpiece first before other commands.<br>• SETUP is the value that calls the stored work setting number, and PROD is the value that calls the stored workpiece number.<br>• When the relevant commands are received and processed normally by the Pick-it equipment, the processing results will be sent to the robot.<br>• In the Pick-it equipment, the results of receiving Configure will be stored in PICKIT.STATUS.<br>• Refer to Chapter 4 of this manual and also to the Pick-it Equipment Manual for the detailed description. | | |

**Note**

- To input a Pick-it statement, select it from 『PICKIT statement』 after going to『[F6]: Command input』 → 『[F3]: Others』→『PREV/NEXT』 in the statement JOB edit window.

### 3.1.2. PICKIT.CHK

| | | | |
|---|---|---|---|
| **Description** | A statement that demands information on the current operation mode of the Pick-it equipment | | |
| **Syntax** | • PICKIT.CHK | | |
| **Parameter** | None | | |
| **Example of usage** | • PICKIT.CHK<br>• (Demands the current mode information of the Pick-it equipment) | | |
| **Detailed description** | • The PICK.CHK command is a statement relevant to RC_PICKIT_CHECK_MOD.<br>• The Pick-it equipment sends the relevant current mode of the following modes of its own.<br>• Running mode: Relevant to PICKIT_RUNNING_MODE<br>• Idle mode: Relevant to PICKIT_IDLE_MODE<br>• Calibration mode: Relevant to PICKIT_CALIBRATION_MODE | | |

**Note**



- The Pick-it equipment operation status is divided into running mode, idle mode, and calibration mode.
- Running mode is a mode that the equipment enters automatically when the Pick-it server is turned on. In this mode, commands and variable are exchanged continuously with the robot.
- Idle mode is a mode to exit the running mode in the Pick-it user program. In this mode, the equipment does not perform any operation for the robotic work. Also, the user can carry out the work of setting the Pick-it equipment.
- Calibration mode is a mode that the equipment enters when the robot sends a calibration command to the Pick-it equipment in idle mode. In this mode, the Pick-it equipment only receives and processes the calibration command and variable without carrying out other works. Refer to the Pick-it Equipment User Manual for the detailed description.

### 3.1.3. PICKIT.LFO

| | | | |
|---|---|---|---|
| **설명** | Commands the Pick-it equipment to carry out picture-taking and identification of workpieces. | | |
| **Syntax** | • PICKIT.LFO P1 | | |
| **Parameter** | PNumber | Variable to store the pose of the identified workpiece | P1 ~ P9999 |
| **Example of usage** | • PICKIT.LFO P1<br>• (Identifies a workpiece in the picture and store the pose of the first workpiece as P1) | | |
| **Detailed description** | • PICKIT.LFO is a statement corresponding to RC_PICKIT_LOOK_FOR_OBJECT.<br>• When receiving the PICKIT.LFO command, the Pick-it equipment takes a picture and identifies a workpiece with the camera.<br>• It will take about two seconds or less to process the recognition of a workpiece.<br>• The picture of the identified workpiece will be stored in the storage memory of the Pick-it equipment. The picture of the first workpiece will be sent directly to the robot, along with the PICKIT.LFO statement processing result, without being stored in the memory.<br>• The sent pose value will be stored in “P#.”<br>• # means a number and can be designated freely by the user.<br>• The Pick-it equipment provides the position and pose of a workpiece based on the robot coordinate or base coordinate.<br>• The coordinate direction of the workpiece posture to be provided to the Pick-it equipment will be determined according to the Pick-it equipment setting. | | |

**Note**

- The Pick-it equipment does not identify workpieces one by one but as many as possible and store their pictures in the internal memory in the queue format. This is because it will take a lot of time to identify the workpieces if you configure the work process in the sequence of “Take a picture -> Identify one workpiece -> Process the work -> Take a picture -> Identify one workpiece -> Process the work.”
- The reference coordinate direction of the workpiece posture to be calculated by the Pick-it equipment will vary according to the type of workpiece and the setting of the Pick-it.
- The reference coordinate direction of the workpiece posture can be set parallel to the z-axis of the robot or base coordinate. It also can be set perpendicular to the surface of the workpiece and in the direction of penetrating from the ground to the ground at the same time.

### 3.1.4. PICKIT.NXT

<table>
<tr><td>Description</td><td colspan="3">A statement that sends the pose of the identified workpiece stored in the Pick-it memory</td></tr>
<tr><td>Syntax</td><td colspan="3">• PICKIT.NXT P1</td></tr>
<tr><td>Parameter</td><td>P Number</td><td>Variable to store the pose of the identified workpiece</td><td>P1 ~ P9999</td></tr>
<tr><td>Example of usage</td><td colspan="3">• PICKIT.NXT P1<br>• (Store the pose of the next workpiece, among the workpieces stored in the memory, as P1)</td></tr>
<tr><td>Detailed description</td><td colspan="3">• PICKIT.NXT is a statement corresponding to RC_PICKIT_NEXT_OBJECT.<br>• When receiving the PICKIT.NXT command, the Pick-it equipment will send the pose values of the workpieces stored in memory one by one in order.<br>• The sent pose value will be stored in the “P Number.”<br>• The P Number can be designated arbitrarily by the user.</td></tr>
</table>

**Note**

- PICKIT.NXT is a statement relevant to PICKIT.LFO. When the PICKIT.LFO command is sent, the Pick-it equipment identifies the workpieces and sends the pose of the first workpiece among them. The pose values of the other workpieces will be stored in the memory. When the PICK.NXT command is received, the pose values will be sent one by one. The process can be performed until the number of remaining workpieces is 0. The number of remaining workpieces can be checked through PICKI.REMIN.

### 3.1.5. PICKIT.ITF

| | | | |
|---|---|---|---|
| **Description** | A statement that designates the settings required for the interoperation with Pick-it communication. | | |
| **Syntax** | • PICKIT.ITF ENETNUMBER,CNX=NUMBER,WAIT=NUMBER | | |
| **Parameter** | ENETNUMBER | ENET number | 1-3 |
| | CNXNUMBER | Periodic sending of robot pose on/off | 1 (ON), 0 (OFF) |
| | WAIT | Pick-it result wait time (second) | 0-20 |
| **Example of usage** | • PICKIT.ITF ENET1,CNX=1,WAIT=3<br>• (ENET1 in use, Periodic sending of robot pose on, Pick-it result wait set for three seconds) | | |
| **Detailed description** | • PICKIT.ITF is a statement that is used to input the setting values for the Pick-it interface internally in the robot controller.<br>• ENETNUMBER is for designating the ENET number to use.<br>• CNX is for determining whether the robot sends the pose information periodically to the Pick-it equipment.<br>• Even when CNX is set to 0, the work of interoperating with the Pick-it equipment can be carried out.<br>• WAIT is for setting the number of seconds to wait between sending a command and receiving the result.<br>• If there is no response from the Pick-it equipment for more than the set time, the processing of the statement is considered to be a failure and PICKIT.STATUS will become -1. | | |

**Note**

- The robot and the Pick-it equipment communicate using Ethernet. The robot controller can simultaneously communicate with three pieces of equipment at the same time. For this, it is required to set and differentiate the Ethernet connection for each device as ENET1, ENET2, and ENET3.
- The Pick-it equipment should periodically receive the robot position and pose variable to estimate the robot pose. CNX commands the start and stop of the periodic sending of the robot pose information. When CNX is set to 1, the periodic sending of the robot pose will start. When CNX reaches 0, the process will stop. CNX must be set to 0 at the end to ensure that the sending of the robot pose can stop when all the works in the JOB file are finished.
- WAIT is a variable that determines the waiting time for the Pick-it processing result. If the waiting time exceeds the set value, it will be judged that there is no response from the Pick-it equipment, and the robot will not wait any longer and will judge the processing result of the command to be a failure. When PICKIT.STATUS is checked and the stored value is found to be -1, it should be judged to be a failure.
- When it comes to the ENET setting for the controller communication, refer to the Ethernet part of the Hi5a Controller Manual.

### 3.1.6. PICKIT.FCP

| | | | |
|---|---|---|---|
| **Description** | A command to calibration the Pick-it equipment | | |
| **Syntax** | • PICKIT.FCP | | |
| **Parameter** | None | | |
| **Example of usage** | • PICKIT.FCP<br>• (Sends a command to find the calibration plate in the picture and perform calibration) | | |
| **Detailed description** | • PICKIT.FCP is a statement corresponding to RC_PICKIT_FIND_CALIB_PLATE.<br>• It will be used to calibrate the Pick-it and robot coordinates.<br>• The robot should move in the Pick-it calibration mode, and then the command should be sent in a condition in which the plate can be seen.<br>• Moving the robot and sending the command should be performed five times in total to complete the calibration. | | |

**Note**



- For the Pick-it equipment to send the workpiece pose based on the robot coordinate, calibration is needed.
- PICKIT.FCP commands the Pick-it equipment to identify the calibration plate and synchronize the robot coordinate and Pick-it coordinate using the robot pose value at this moment.
- Plate detection must be performed five times in total to complete the calibration.
- Refer to the Pick-it Equipment Manual for the detailed description.

## 3.2. Pick-it Variable

### 3.2.1. PICKIT.STATUS

| | | | |
|---|---|---|---|
| **Description** | A variable to store the Pick-it status value | | |
| **Syntax** | • PICKIT.STATUS | | |
| **Parameter** | None | | |
| **Example of usage** | • IF PICKIT.STATUS=0 THEN 3 ELSE 99<br>• (If PICKIT.STATUS is 0, a movement to the Row 3 number or to the Row 99 number will occur.)<br>• PRINT #0,PICKIT.STATUS<br>• (Output of the Pick-it status value remaining in the TP window) | | |
| **Detailed description** | • PICKIT.STATUS is a variable to store the processing result of the PICKIT statement<br>• A built-in type variable that does not have to be declared as a variable separately Stores the processing results of PICKIT.CFG, PICKIT.CHK, PICKIT.LFO, PICKIT.NXT, and PICKIT.FCP<br>• -1 will be stored if there is no response from the Pick-it equipment for the wait time<br>• The result value will be stored in an integer value, as shown below.<br>• PICKIT_RUNNING_MODE : 0<br>• PICKIT_IDLE_MODE : 1<br>• PICKIT_CALIBRATION_MODE : 2<br>• PICKIT_FIND_CALIB_PLATE_OK : 10<br>• PICKIT_FIND_CALIB_PLATE_FAILED : 11<br>• PICKIT_OBJECT_FOUND : 20<br>• PICKIT_NO_OBJECTS : 21<br>• PICKIT_NO_IMAGE_CAPTURED : 22<br>• PICKIT_CONFIG_OK : 40<br>• PICKIT_CONFIG_FAILE : 41 | | |

**Note**

- The statement processing result will be transferred from the Pick-it equipment, and the result will be stored in numbers.
- It is convenient to declare each result value as a variable in a JOB file and process it accordingly.
- For a description about the status value, refer to the Pick-it Equipment Manual.

### 3.2.2. PICKIT.REMAIN

| | | | |
|---|---|---|---|
| **Description** | A variable that stores the count of identified workpieces stored in the current remaining memory | | |
| **Syntax** | • PICKIT.REMAIN | | |
| **Parameter** | None | | |
| **Example of usage** | • V1%=PICKIT.REMAIN: Stores PICKIT.REMAIN in V1%.<br>• IF PICKIT.REMAIN > 0 THEN 8 ELSE 99: If PICKIT.REMAIN is larger than 0, a movement to the Row 8 number or to the Row 99 number will occur.<br>• PRINT #0,PICKIT.REMAIN: Output of the count of the workpieces remaining in the TP window) | | |
| **Detailed description** | • PICKIT.REMAIN is a variable that stores the count of the remaining workpieces.<br>• A built-in type variable that does not have to be declared as a variable separately.<br>• It will be updated after the PICKIT.LFO and PICKIT.NXT commands are processed.<br>• The workpiece pose values are stored as many as the count of PICKIT.REMAIN | | |



**Note**

- The Pick-it equipment identifies all identifiable workpieces rather than identifying only a single workpiece in the picture taken once.
- The Pick-it server stores the count of identified workpieces and their pose information.

### 3.2.3. PICKIT.TYPE

| | | | |
|---|---|---|---|
| **Description** | A variable that stores the type of an identified workpiece | | |
| **Syntax** | • PICKIT.TYPE | | |
| **Parameter** | None | | |
| **Example of usage** | • V1%=PICKIT.TYPE<br>• (Stores PICKIT.TYPE in V1%)<br>• IF PICKIT.TYPE = 21 THEN 8 ELSE 99<br>• (If PICKIT.TYPE is 21, a movement to the Row number 8 and to the row number 99 will occur.)<br>• PRINT #0,PICKIT.TYPE<br>• (Output of the form of the workpiece in the TP window) | | |
| **Detailed description** | • PICKIT.TYPE stores the type of the workpiece whose pose value is transferred.<br>• A built-in type variable that does not have to be declared as a variable separately<br>• It will be automatically updated after the PICKIT.LFO and PICKIT.NXT commands are processed.<br>• The workpiece pose values are stored in the Pick-it server as many as the count of PICKIT.REMAIN.<br>• The values that TYPE can have are as shown below.<br>• 21 for square<br>• 22 for rectangle<br>• 23 for circle<br>• 24 for ellipse<br>• 32 for cylinder<br>• 33 for sphere<br>• 35 for point cloud<br>• 50 for blob | | |



**Note**

- The Pick-it equipment can recognize not only the workpieces of basic types, such as cylinders and cubes, but also those of complex types.
- For information on how to recognize the workpieces of complex types, refer to the Pick-it Manual.

### 3.2.4. PICKIT.DIM0 / DIM1 / DIM2

| | | | |
|---|---|---|---|
| **Description** | Informs the dimension of the identified workpiece. | | |
| **Syntax** | • PICKIT.DIM0<br>• PICKIT.DIM1<br>• PICKIT.DIM2 | | |
| **Parameter** | None | | |
| **Example of usage** | • V1%=PICKIT.DIM0<br>• (Stores DIM0 in V1%)<br>• IF PICKIT.DIM1 > 100 THEN 8 ELSE 99<br>• (If PICKIT.DIM0 is larger than 100, a movement to the Row 8 number or to the Row 99 number will occur.)<br>• PRINT #0,PICKIT.DIM0<br>• (Output of the DIM0 of the workpiece in the TP window) | | |
| **Detailed description** | • PICKIT.TYPE stores the size of the workpiece whose pose value is transferred.<br>• A built-in type variable that does not have to be declared as a variable separately<br>• It will be updated after the PICKIT.LFO and PICKIT.NXT commands are processed.<br>• Whether the value of DIM0, DIM1, or DIM2 exists and what it means will vary depending on the type of the workpiece.<br>• DIM0: Length or diameter (Unit: mm)<br>• DIM1: Width or diameter (Unit: mm)<br>• DIM2: Height (Unit: mm) | | |

**Note**

- The information of DIM0, DIM1, and DIM2 will vary depending on the type of the workpiece.
- Workpiece of square: DIM0 and DIM1 for the length of the two sides of the square
  Workpiece of rectangle: DIM0 and DIM1 for the length of two sides of the rectangle
  Workpiece of circle: DIM0 and DIM1 for the diameter of the circle
  Workpiece of ellipse: DIM0 and DIM1 for the length and width of the ellipse
  Workpiece of cylinder: DIM0 and DIM1 for the length and diameter of the cylinder
  Workpiece of sphere: DIM0 and D1M1 for the diameter of the sphere
  Point cloud: DIM0, DIM1, and DIM2 for the length, width, and height of the box processed with point cloud
  Workpiece of bob: DIM0, DIM1, DIM2 for the length, width, and height processed with a blob
- For the added or changed information, refer to the Pick-it Equipment Manual and the website.

HD HYUNDAI ROBOTICS

# 4 Pick-it JOB Files

## 4.1. Procedures for the Interface between the Robot and the Pick-it Equipment

### 4.1.1. Overview of the interface

Figure 4-1 shows the procedure for constructing the system using the robot and Pick-it equipment and performing the works. What should be performed in the individual procedures is as follows.

(1) Install and configure the robot, Pick-it equipment, and communication equipment. Refer to individual manuals for configuring the robot and Pick-it equipment. Refer to Chapter 2 of this manual for Ethernet communication configuration.
(2) Access the Pick-it server through the Chrome web browser and make basic settings.
(3) When it comes to the robot of Hyundai Robotics, it is required to enter the pages for user environment, control parameters, and robot parameters and make settings, such as coordinates and Ethernet communication, using a TP.
(4) Write the JOB files of the work to perform using Hyundai Robotics' commands for Pick-it applications. The JOB files to write include the ones for calibration and bin-picking.
(5) Attach a calibration plate to the flange of the robot, and calibrate the Pick-it coordinate to the robot coordinate using the JOB file for calibration.
(6) When the Pick-it coordinate calibration is completed, let the robot pick the workpiece using the JOB file.

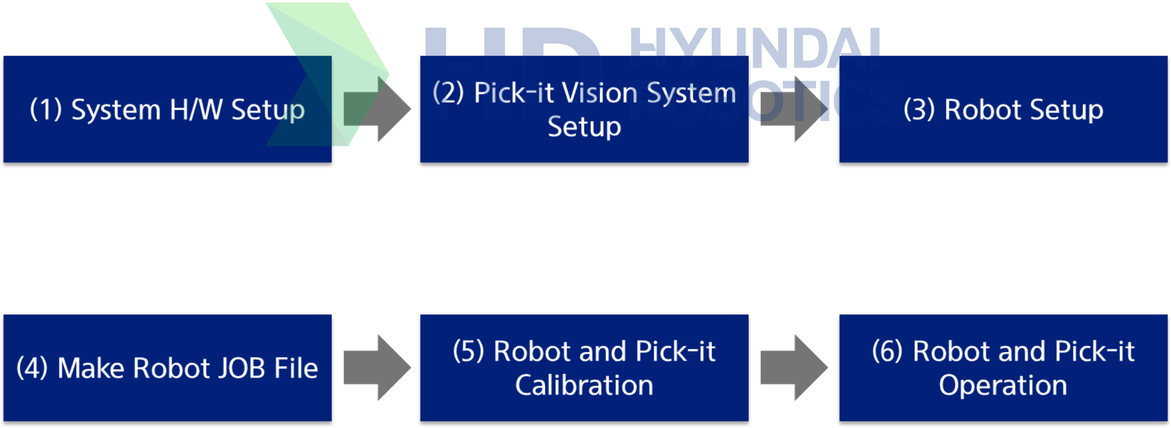


**Figure 4-1 Procedures for interface between the robot and Pick-it equipment**

To allow the robot to perform works, calibration should be performed first. After that, the works can be performed using the robot and Pick-it equipment. This chapter first describes how to calibrate the Pick-it coordinate to the robot coordinate by writing a JOB file that makes it possible to control the robot and give commands to the Pick-it equipment. The chapter also describes how to allow the robot to perform picking by writing a JOB file that allows commands and variable to be sent and received between the robot and Pick-it equipment and allows the robot to perform picking by receiving the pose of the workpiece from the Pick-it equipment.

## 4.2. Description of Calibration

### 4.2.1. Procedures for calibration

To use the Pick-it equipment, it is required to calibrate the Pick-it coordinate to the robot or base coordinate. The Pick-it camera calibration is performed before shipment, so there is no need to do it separately. (Refer to the Pick-it Manual.)

However, when the Pick-it equipment is shipped, the coordinates that the Pick-it equipment will use to calculate the workpiece position and posture are not calibrated to the robot coordinate. So after the robot and Pick-it equipment are physically installed, it is required to calibrate the Pick-it coordinate to the robot coordinate.

For this, Pick-it provides a way for calibration to be performed automatically through the use of the calibration plate instead of the manual method in which the user directly inputs coordinate values in the Pick-it setting screen. In the automatic calibration method, the camera will take a picture of the calibration plate at various positions and postures and then use the acquired robot pose information in performing calibration.

### 4.2.2. Methods of calibrating according to camera mounting position

There are two methods of using the calibration plate depending on how to install the Pick-it camera. The camera installation method is divided into the method of attaching the camera on the robot arm and the method of installing it on a fixed support instead of the robot.

First, in the method of installing the camera on the robot arm, it is required to fix the calibration plates on the floor and then take a picture of the calibration plate by moving the robot pose along with five different positions and postures. If the camera needs to be mounted to a fixed support rather than a robot, the calibration plate should be installed to the robot flange and should be taken a picture of by posing the robot along with five different positions and postures. Both methods go through the same procedures in that the calibration should be performed by taking a picture of the calibration plate along with five different positions and postures while differing only in the camera installation position.

Figure 4-2 shows how to install the camera on a fixed support outside the robot and calibrate the Pick-it equipment to the robot. As shown in the figure, the camera is installed at a position where the workpiece can be seen well, and the calibration plate is mounted on the robot flange. To calibrate the Pick-it equipment to the robot coordinate, it is required to move the robot to a different position and posture and then make the robot send the PICKIT.FCP command to the Pick-it equipment each time, as shown in Figure 4–3. The entire process should be performed five times in total. The precaution to take when the robot takes a position and posture is that at least three of the markers on the four corners of the calibration plate should be seen through the camera. For detailed procedures and precautions for calibration, refer to the Pick-it Manual.


Figure 4-2 Camera attached to a support

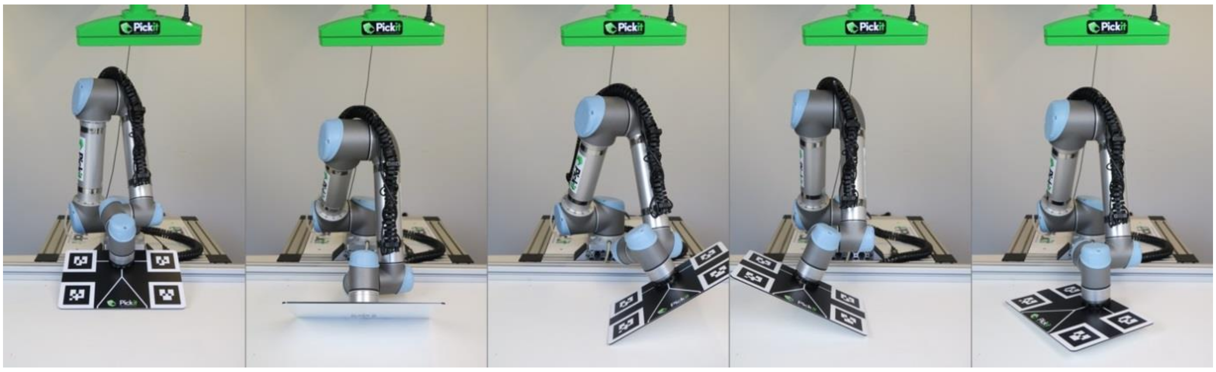

Figure 4-3 Change of posture for calibration with the camera attached to a support

In the method of attaching the camera on the robot flange, as shown in Fig. 4-4, fix the calibration plate on the floor and perform the calibration procedure by changing the positions and postures of the camera and robot. In this case, the robot should send the PICKIT.FCP command to the Pick-it equipment whenever taking a different position and posture. The precaution to take is that at least three of the four markers on the four corners of the calibration plate should be seen through the camera picture-taking region in the same manner as shown above.

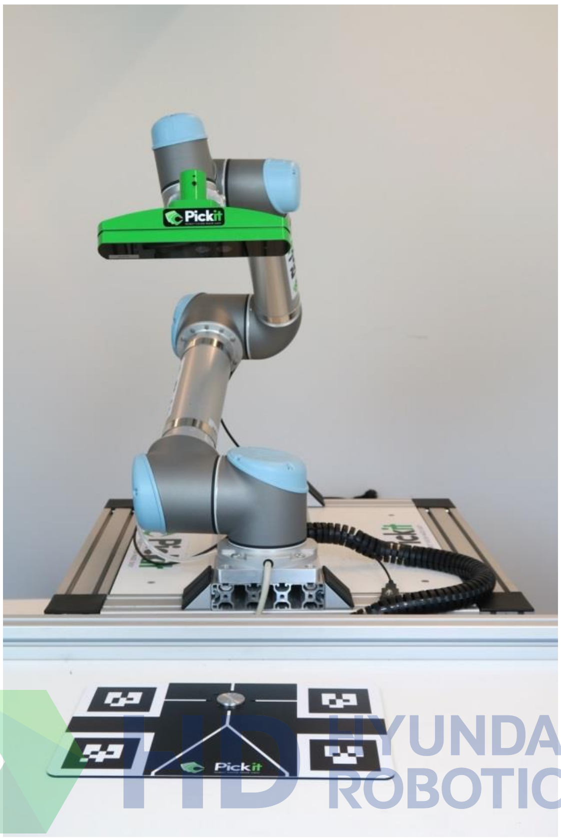


Figure 4-4 Camera mounted on the robot flange

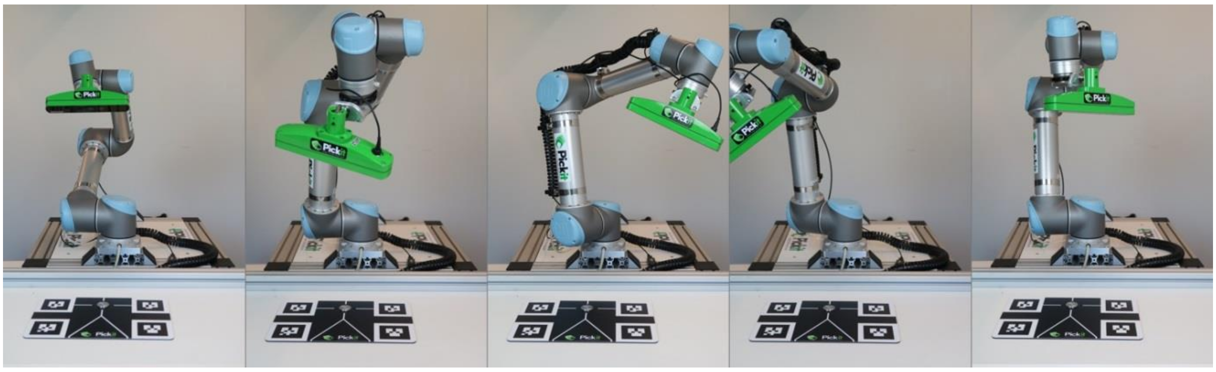

Figure 4-5 Change of posture for calibration with the camera attached to the robot flange

### 4.2.3. Methods of calibrating according to the robot operation

It is described above that there are two methods of calibrating the Pick-it equipment to the robot coordinate depending on the mounting position of the camera. The two methods differ only in the mounting position of the camera, and the calibration process is exactly the same.

When performing the calibration, it is required to take a total of five different positions and postures and send the PICKIT.FCP command each time. For this process, there are two methods of performing the calibration according to the method of the robot taking a posture and sending a command.

(1) Change the robot position manually and execute the PICKIT.FCP command.

(2) Store five pose variables in advance and execute MOVE and PICKIT.FCP commands in JOB file repeatedly.

The method (1) is to manually execute the PICKIT.FCP command in the JOB after manipulating the position and posture of the robot while looking at the Pick-it camera screen. The method is advantageous in making it possible to flexibly carry out calibration according to the given situation while looking at the Pick-it control screen after manipulating the robot position and posture. This method is convenient in a situation where only one robot needs to be calibrated.

The method (2) is to store five different postures and positions in the pose variable in advance and execute the MOVE and PICKIT.FCP commands in the JOB file. Considering that it is required to perform work after storing the positions and postures in advance, meaning that if calibration cannot be carried out because the robot pose is wrong, you have to perform the whole calibration work again starting from the point of storing the robot pose, which is disadvantageous using the method. However, since the robot pose and calibration process are stored as a JOB file, it is possible to apply the JOB file without modifying it as long as the robot and workstation are allocated in the same way, which is advantageous in using the method.

The detailed description of the process of the two methods will be provided in the following examples of JOB files.

### 4.2.4. Precautions to take when calibrating

The precaution to take in performing calibration is that the tool length and posture in the tool information must be set to 0. In other words, it is required to set the robot coordinate while there is no tool, and then send the position and posture information to the Pick-it equipment. If work was performed previously by setting the coordinate tool value, it is required to delete the value or change to a different tool that has the value of 0 and then perform the calibration. It is required to set the tool information before performing works by actually interoperating the robot and Pick-it equipment after the calibration is completed.

# 4.3. Example of Calibration

This example of calibration describes not only the manual calibration method that the TP is manually operated to carry out calibration but also the automatic calibration method that five different robots pose variable are stored in advance, and the calibration is carried out by loading the variable in the JOB file.

## 4.3.1. Manual calibration

In manual calibration, it is required to send the PICKIT.FCP command after manipulating the robot position and pose using the TP while checking whether the calibration plate can be seen through the Pick-it control screen. Figure 4-6 shows the manual calibration flow chart.

The manual calibration can be described as briefly as the following: move the robot using the TP, and check whether the calibration plate is seen through the Pick-it setting screen. Then, manually select and send the PICIIT.FCP command in the JOB file using the TP. Considering that the work is performed by looking at the calibration plates in the Pick-it setting screen, it is possible to carry out calibration while flexibly corresponding to the processing results.

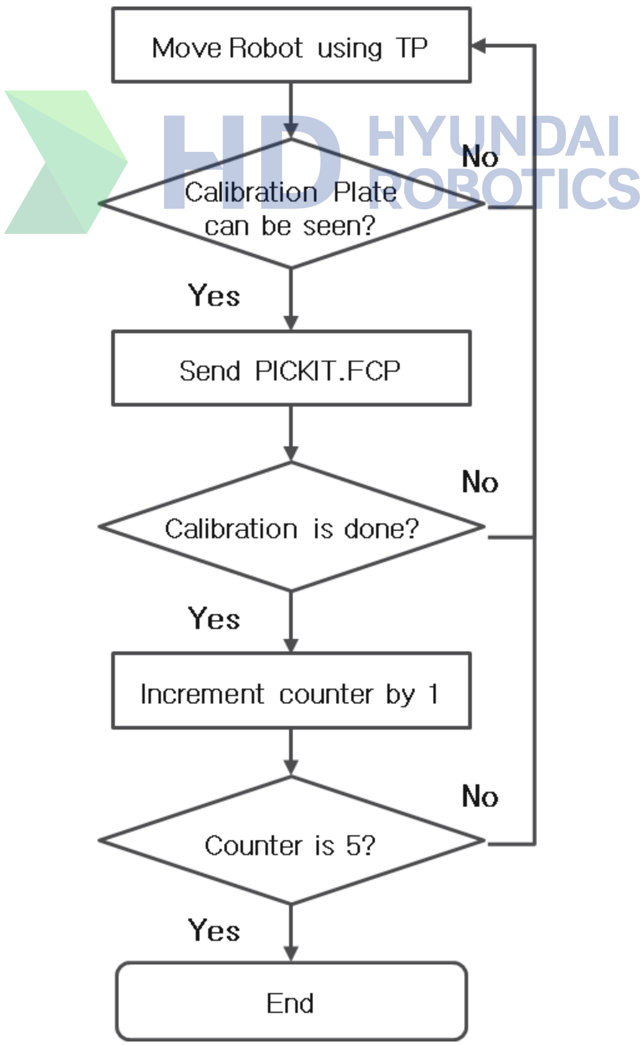


**Figure 4-6 Manual calibration flow chart**

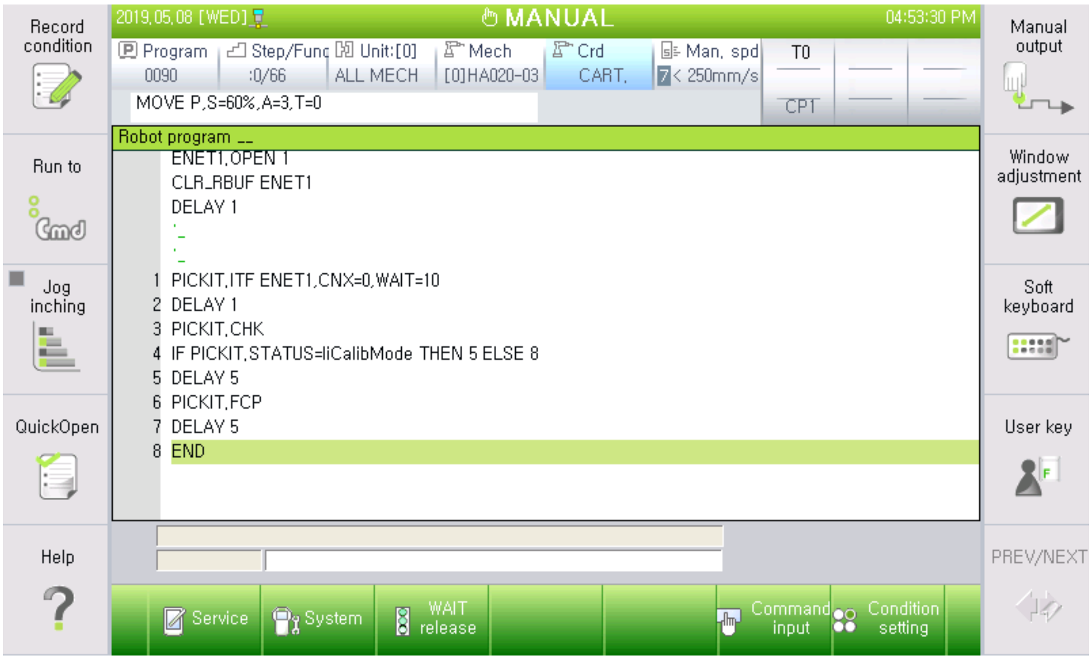


**Figure 4-7 Manual calibration JOB file**

The method to carry out manual calibration is described together with the JOB file as below. This method must be performed with the robot controller in manual mode. Set the execution unit as Cmd and carry out the operation using the “STEP FWD” and “STEP BWD” keys.

(1) In the Pick-it setting screen, stop the Run mode and move to the calibration screen.

(2) In the JOB file, perform calibration up to the variables useful for settings in the unit of Cmd. (Refer to the JOB file in the appendix for the detailed definition of variables.)

(3) Perform calibration up to the Ethernet setting statement in the unit of Cmd.

(4) Perform calibration up to the PICKIT.ITF interface setting, as described in the statement of Row 1 in Figure 4-7. In this process, it is required to set CNX=0 to deactivate the function of sending the robot pose to the Pick-it equipment periodically.

(5) When reaching Row 5 after performing calibration from Row 2 up to Row 4, it is required to stop JOB file execution and then change the position and posture by moving the robot using the TP jog. In this process, while looking at the Pick-it setting screen, check whether at least three of the markers on the four corners of the calibration plate can be seen while the calibration plate is captured by the screen.

(6) Move to the PICKIT.FCP statement and perform calibration in the unit of Cmd. The DELAY statement in the JOB file is for acquiring the time for stopping Cmd execution before moving to the next statement.

(7) Until the entire calibration process is completed, perform the above (5) and (6) steps five times in total by moving to the PICKIT.FCP statement.

## 4.3.2. Automatic calibration

Automatic calibration is a method to process five different robot poses stored in advance and PICKIT.FCP in a JOB file. Compared to the manual calibration, in automatic calibration, the JOB file is complex, and there is inconvenience of storing the robot pose in the variable in advance, while, instead, the same JOB file can be recycled when calibration needs to be performed later or applied to several robots in the same environment, which are advantageous points. When performing automatic calibration, it is required to set the JOB file for automatic and 1 cycle execution.

Figure 4 - 8 shows the automatic calibration flow chart

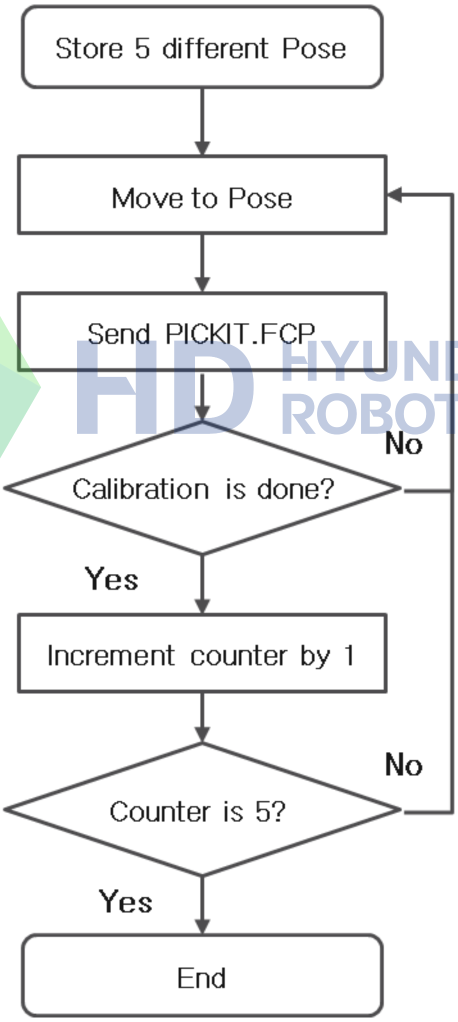


**Figure 4-8 Automatic calibration flow chart**

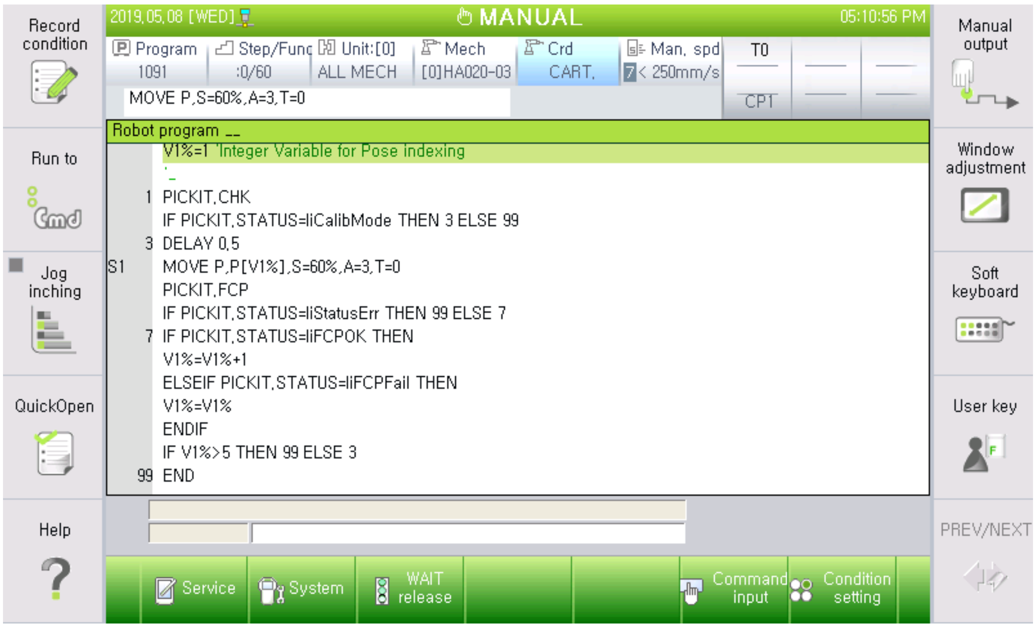


**Figure 4-9 Automatic calibration JOB file**

(1) While looking at the Pick-it setting screen, let the robot take five different poses using the TP, and then, store them in five pose variables.

(2) In the Pick-it setting screen, stop the Run mode, and move to the Calibration screen.

(3) Execute the Job file for the automatic calibration.

(4) Set 1 as the variable value to designate the pose number (for setting the first pose variable).

(5) Check the current Pick-it mode in Row 1 of the JOB file.

(6) If the Pick-it is not in the calibration mode, the JOB file execution should be ended.

(7) The robot will move to the position and posture of the pose variable relevant to the pose number designation variable among the pose variables inputted in advance.

(8) After moving to the position of the pose variable, the robot will execute the PICKIT.FCP statement.

(9) The Pick-it equipment will receive and process the PICKIT.FCP command and send the processing result to the robot.

(10) If there is no response from the Pick-it equipment, PICKIT.STATUS will contain an error value (-1). Then, the robot will end the JOB file execution.

(11) If the Pick-it equipment succeeds in carrying out calibration normally, the pose number designation variable will be increased by 1. If it fails, the pose number designation variable will be left as it is without being increased.

(12) If the pose number designation number is 5 or below, it is required to move to the step (7) and perform calibration continuously. If the number exceeds 5, it means the completion of calibration. Then, the calibration work will be completed.

## 4.4. Example of Bin Picking JOB File

This chapter describes the JOB file process of picking a workpiece through the interoperation between the Pick-it equipment and the robot.

### 4.4.1. Procedures for bin picking

The detailed procedures that the robot should perform in the picking work using the Pick-it equipment are as follows.

(1) Setting the robot Ethernet interface and Pick-it interface

(2) Identifying the workpiece in the picture taken by the camera

(3) Acquiring the workpiece pose information

(4) A robot moving to the workpiece pose and picking the workpiece

(5) Checking for any remaining workpiece and continuing the picking work

For the robot and Pick-it equipment to communicate through Ethernet, it is required to set the destination IP address and port number in JOB file. It is also required to set the robot interface to interoperate with the Pick-it equipment. The PICKIT.ITF statement should be used for setting the interoperation with the Pick-it equipment. PICKIT.ITF designates the Ethernet number to be used by the robot and Pick-it equipment, whether to send the robot pose information periodically, and how many seconds to wait to receive the Pick-it processing result. In this process, even if the user performs the setting in a way not to send the robot pose periodically, the interoperation with the Pick-it equipment is still possible. However, it is recommended to perform the setting in a way to send the robot pose periodically for optimal performance.

In the next process, it is required to send a command to the Pick-it equipment for it to identify a workpiece and receive the workpiece pose as a result. The robot moves and performs the work according to the transferred pose information of the workpiece, checks whether there is a remaining workpiece, and continues the picking work.

PICKIT.LFO can be used to check whether there is any remaining workpiece to pick, but processing in that way will take time. It is efficient to get the workpiece pose stored in the Pick-it buffer by using the PICK.NXT statement. In this process, the precaution to take is that if the position of another workpiece moves when the robot carries out picking, the pose of the remaining workpiece stored in the Pick-it buffer will change, making it impossible to carry out picking properly. If that happens, it is required to execute PICKIT.LFO newly.

### 4.4.2. Example of the bin picking JOB file

The JOB file to perform bin picking is largely divided into four parts.

(1) Setting the robot Ethernet interface and Pick-it interface

(2) Executing the PICKIT.LFO statement and picking by the robot

(3) Executing the PICKIT.NXT statement and picking by the robot

(4) Ending the work and interface


**Figure 4-10 Bin picking JOB file (1)**

The first thing to do in the JOB file is to set the robot controller's Ethernet. The Ethernet address to export variables and commands from the robot is "192.168.1.11" as the IP address of the UDP2TCP converter. The port number for the UDP2TCP converter should be set to "5001," and the one for the robot controller should be set to "5001." After the setting, it is required to open the Ethernet with the ENET1.OPEN statement to use it.




**Figure 4-11 Bin picking JOB file (2)**

It is required to set the robot controller's Ethernet and the Pick-it interface. In the example, ENET1 is used, and CNX is set to 1 to send the variable from the robot controller to the Pick-it equipment internally, and the Pick-it processing result wait time is set to three seconds. In the Pick-it setting screen, the setup file #12 stored in advance will be loaded, and the type of workpiece is selected as 19. If the above procedures are performed normally, the liCFGOK (=40) result will be transferred from the Pick-it equipment and stored in PICKIT.STATUS.

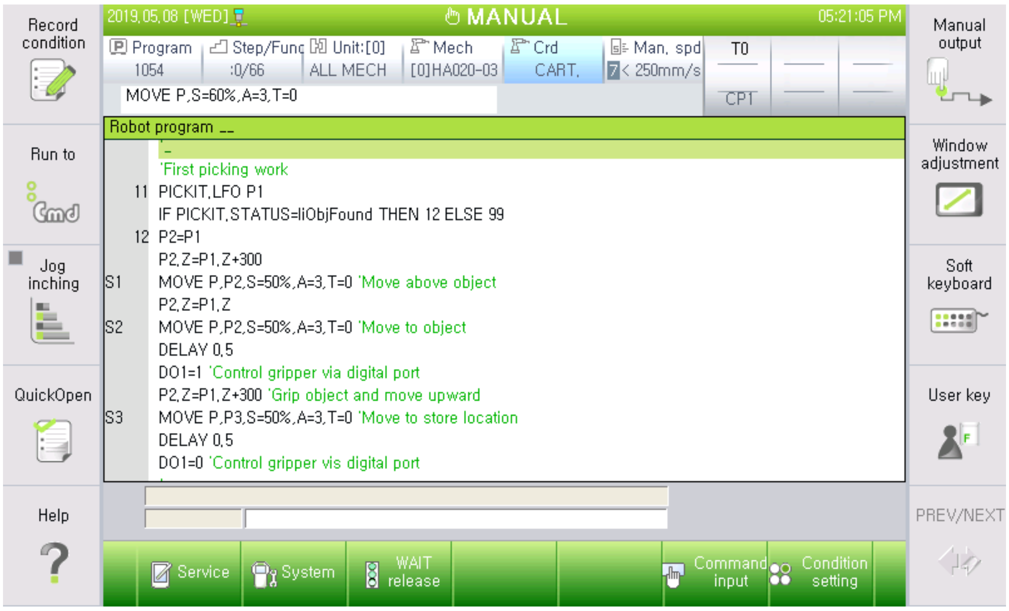


**Figure 4-12 Bin picking JOB file (3)**

Once the setting of the robot controller and Pick-it equipment is completed, the PICKIT.LFO command should be sent to the Pick-it equipment to identify the workpiece. If the Pick-it equipment identifies the workpiece, the pose of the identified workpiece will be stored in P1, and the IiObjFound (= 20) result will be stored in STATUS. The workpiece pose will be stored in P1 and, then, the robot will move over the position of the P1 pose and vertically downward. Next, the robot will control the gripper to pick the workpiece and move to the loading position P3 and release the picking mode. For this process, the P3 pose variable should be set in advance.

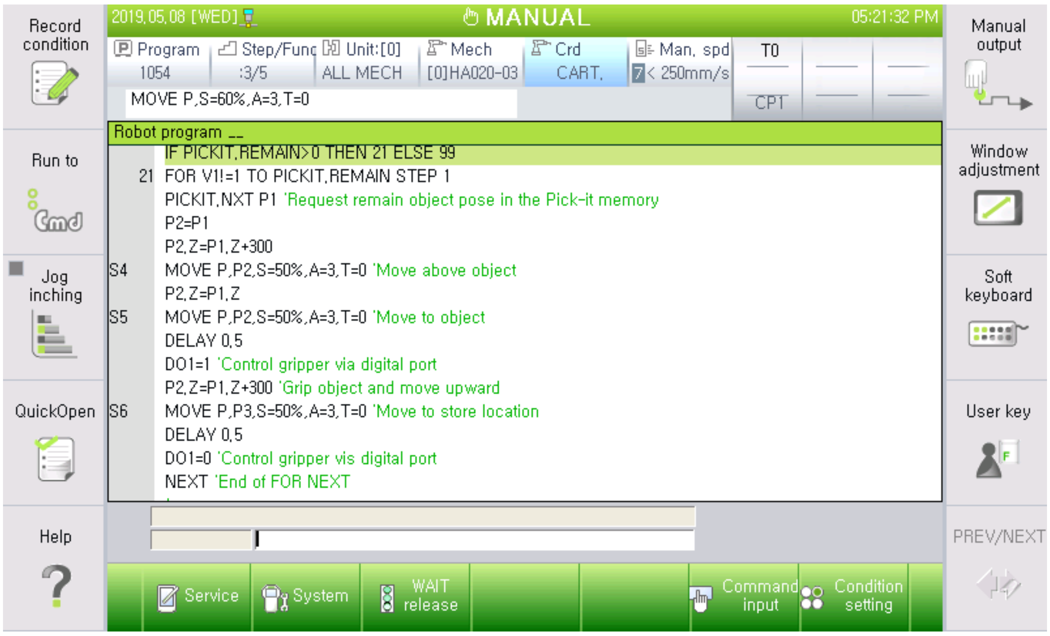


**Figure 4-13 Bin picking JOB file (4)**

When receiving the PICKIT.LFO statement, the Pick-it equipment takes a picture using the camera and identifies the workpiece. In this process, instead of identifying only one workpiece, the equipment identifies all possible workpieces and stores the pose of each workpiece in the memory.

When the robot is required to pick a large number of workpieces, the operation may take place in a way that the PICKIT.LFO command is sent to receive and process the pose of one workpiece; then, the PICKIT.LFO command is sent to receive and process the pose of the next workpiece; and so on. However, there will be a problem of taking lots of time to process the picture in this way. So instead of using the PICKIT.LFO commands consecutively, it will be efficient to send the PICKIT.LFO command once, and then use the PICKIT.NXT statement to receive the poses of the remaining workpieces stored in the Pick-it memory.

In the above JOB file example, after the PICKIT.LFO statement is processed, the count of the poses of the workpieces remaining in the memory will be checked and, the PICKIT.NXT statement will be used to receive the workpiece poses as many as the count and perform the picking work. The operation will be the same as the one for processing the PICKIT.LFO statement, except that the PICKIT.NXT and FOR NEXT commands are used instead in this method.

The precaution to take in this process is that if the position and posture of the remaining workpieces changes during the picking work, the position and posture of the workpieces that remain will differ from the position and posture information of the workpiece remaining in the Pick-it memory. Because of this, it is required to perform the process of identifying the workpieces newly by using the PICKIT.LFO command.

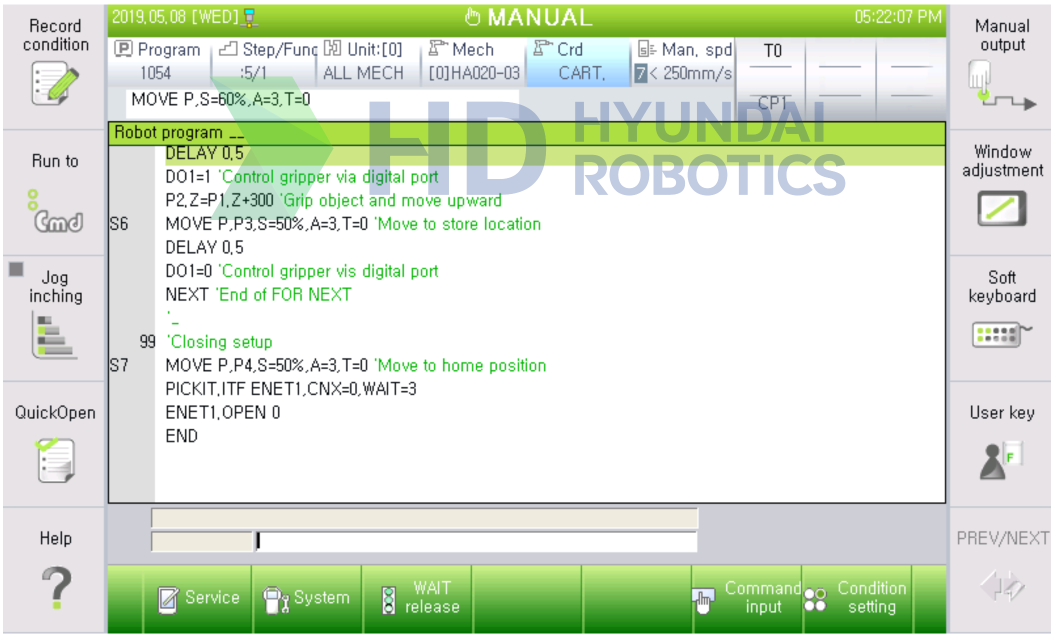

**Figure 4-14 Bin picking JOB file (5)**

When the work of picking and loading workpieces is finished, it is required to safely move the robot to the home pose and set “CNX=0” to stop the operation of sending variable periodically internally from the robot controller to the Pick-it equipment. Then, release the Ethernet connection.

# 5
# Precautions

## 5.1. Pick-it Equipment

### 5.1.1. Mounting of the calibration plate

The calibration plate provided by Pick-it has screw holes for mounting the Pick-it equipment on the robot flange. There are several screw holes for compatibility with diverse robots. However, they may not match the screw holes of the flange in the position and size in some cases. In this case, contact Pick-it for inquiry, or the user is required to make and use a separate calibration plate.

The calibration plate has a small circular plate in the form of a button for the bonding with the robot flange. It is desirable for the center of the circular plate to match the center of the flange. Even when they do not match, it will not interfere with calibration. However, the calibration plate should be firmly fixed so that it does not shake or move.

### 5.1.2. Pick-it server rebooting

If the Pick-it server is left unattended for a few days without interoperating with the robot, it may not work properly in some cases. In this case, it is required to reboot the server by disconnecting and connecting the power supply to the Pick-it server.

## 5.2. Installation of the robot of Hyundai Robotics

There are no separate precautions to take in installing the robot of Hyundai Robotics to use the Pick-it equipment; just be cautious about where to mount the camera. Depending on the characteristics of the workpiece, the Pick-it cameras can be attached to the robot arm or a separate external support. Be cautious about the characteristics of the workpiece when selecting a method.

## 5.3. Connection of systems

### 5.3.1. UDP2TCP converter

The UDP2TCP converter does not require any special settings and can operate immediately when the power is connected. If the converter does not operate after being left unattended for a long time while the power is connected, it is required to turn off the power and turn it on again.

Do not install the UDP2TCP converter in a place with excessive heat. It is more vulnerable to the thermal environment than the hardware of the robot controller, so even when the converter may stop operation even when it is in a thermal condition in which the controller can operate. It is required to pay attention to the installation environment.



### 5.3.2. Ethernet switch

It is required to have an Ethernet switch to connect the Pick-it equipment, the robot of Hyundai Robotics, and the UDP2TCP converter. An ordinary Ethernet switch can be used. For safety, do not connect it to the external internet, but connect it only to the three units of equipment mentioned before. While it is also possible to connect the switch to HRMS to use it, do not connect the switch to the separate external internet even in this case.

## 5.4. Workpiece Coordinate

The workpiece pose value transferred from the Pick-it equipment to the robot will be set in the direction in which the positive Z-axis penetrates the ground vertically, or is vertical to the surface of the workpiece and penetrates the ground, as shown in Figure 5–1. If this posture value is used as it is, problems could occur because it will be impossible to match with the direction of the robot tool coordinate. The robot tool is generally set in the positive z-axis direction facing from the flange toward the outside of the robot arm, as shown in Figure 5-2. If the workpiece posture sent from the Pick-it equipment is used as it is, the tool will be facing toward the robot, causing an error.

To solve this problem, the robot of Hyundai Robotics rotates the workpiece posture internally, sent from the Pick-it equipment by 180°, randomly based on the x-axis as shown in Figure 5-3, and then stores the posture in the pose variable. This allows the tool to take a posture to pick a workpiece. The precaution to take is that the workpiece posture seen through the Pick-it screen is different from the workpiece posture that is used as a pose variable in the robot.

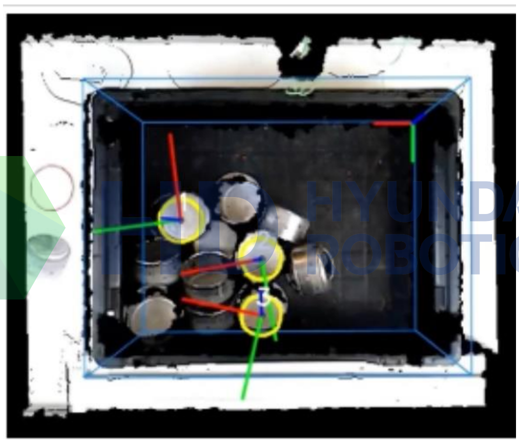

**Figure 5-1 Z-axis direction of the workpiece processed by the Pick-it equipment**

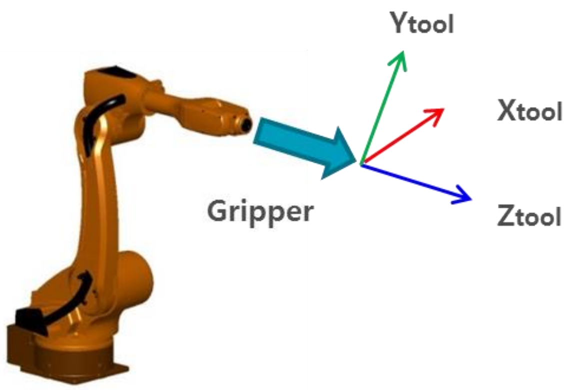


**Figure 5-2 Z-axis direction of the tool coordinate**

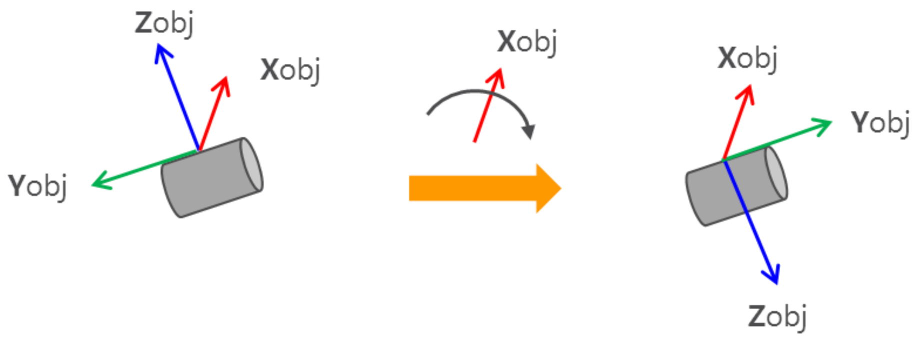


**Figure 5-3 Converting and storing a workpiece posture**

## 5.5. Precautions to Take in Writing a JOB File

Before the robot pose value given by the Pick-it equipment is used in the JOB file, it must be checked whether the pose value is within the safe working area. Since the pose value provided by the Pick-it equipment may not be accurate, it should be checked whether the pose value is within the safe working area before using the MOVE statement. The example of the JOB file presented in this manual excludes the part related to checking whether the pose variable value is within the safe working area.

After the Pick-it operation is finished, it is required to set ITF=0 using the PICKIT.CFG statement. Otherwise, the pose of the current robot will continue to be sent from the robot controller to the Pick-it equipment, possibly wasting resources unnecessarily and causing unintended misbehavior.

HD HYUNDAI ROBOTICS

# 6
# Appendix

## 6.1. Manual Calibration of JOB File

The following shows the entire example of the manual calibration JOB file described in Chapter 4. Refer to Chapter 4 for the detailed description. This file is an example, and operation can be still performed using other methods. For the sake of user convenience, this example can be applied in other methods to write a file.

**Program File Format Version: 1.6 MechType: 127(HA020-03) TotalAxis: 6 AuxAxis: 0**

```
'_Pick-it Manual Calibration
'_Pick-it Mode
DIM liStatusErr AS Integer
DIM liRunMode AS Integer
DIM liIdleMode AS Integer
DIM liCalibMode AS Integer
'_Pick-it Status
DIM liFCPOK AS Integer
DIM liFCPFail AS Integer
DIM liObjFound AS Integer
DIM liNoObj AS Integer
DIM liNoImgCap AS Integer
DIM liCFGOK AS Integer
DIM liCFGFail AS Integer
DIM liSVSOK AS Integer
DIM liSVSFail AS Integer
'_Pick-it Type
DIM liSquare AS Integer
DIM liRectangle AS Integer
DIM liCircle AS Integer
DIM liEllipse AS Integer
DIM liCylinder AS Integer
DIM liSphere AS Integer
DIM liPointCloud AS Integer
DIM liBlob AS Integer
'_
liStatusErr=-1
liRunMode=0
liIdleMode=1
liCalibMode=2
'_
liFCPOK=10
liFCPFail=11
liObjFound=20
liNoObj=21
liNoImgCap=21
liCFGOK=40
liCFGFail=41
liSVSOK=50
liSVSFail=51
'_
liSquare=21
liRectangle=22
liCircle=23
liEllipse=24
liCylinder=32
```

```
    liSphere=33
    liPointCloud=35
    liBlob=50
    '
     _
    ENET1.IP="192.168.1.11"
    ENET1.RPORT=5001
    ENET1.LPORT=5001
    ENET1.OPEN 1
    CLR_RBUF ENET1
    DELAY 1
    '
     _
    '
     _
1 PICKIT.ITF ENET1,CNX=0,WAIT=10
2 DELAY 1
3 PICKIT.CHK
4 IF PICKIT.STATUS=liCalibMode THEN 5 ELSE 8
5 DELAY 5
6 PICKIT.FCP
7 DELAY 5 'Manual execution in the unit of cmd, Stop here, Robot moves, Execute movement to 6
8 END
```

## 6.2. Automatic Calibration JOB file

The following shows the entire example of the automatic calibration JOB file described in Chapter 4. Refer to Chapter 4 for the detailed description.

```
Program File Format Version: 1.6 MechType: 127(HA020-03) TotalAxis: 6 AuxAxis: 0
     '_Pick-it Auto Calibration
     '_Pick-it Mode
     DIM IiStatusErr AS Integer
     DIM IiRunMode AS Integer
     DIM IiIdleMode AS Integer
     DIM IiCalibMode AS Integer
     '_Pick-it Status
     DIM IiFCPOK AS Integer
     DIM IiFCPFail AS Integer
     DIM IiObjFound AS Integer
     DIM IiNoObj AS Integer
     DIM IiNoImgCap AS Integer
     DIM IiCFGOK AS Integer
     DIM IiCFGFail AS Integer
     DIM IiSVSOK AS Integer
     DIM IiSVSFail AS Integer
     '_Pick-it Type
     DIM IiSquare AS Integer
     DIM IiRectangle AS Integer
     DIM IiCircle AS Integer
     DIM IiEllipse AS Integer
     DIM IiCylinder AS Integer
     DIM IiSphere AS Integer
     DIM IiPointCloud AS Integer
     DIM IiBlob AS Integer
     '_
     IiStatusErr=-1
     IiRunMode=0
     IiIdleMode=1
     IiCalibMode=2
     '_
     IiFCPOK=10
     IiFCPFail=11
     IiObjFound=20
     IiNoObj=21
     IiNoImgCap=21
     IiCFGOK=40
     IiCFGFail=41
     IiSVSOK=50
     IiSVSFail=51
     '_
     IiSquare=21
     IiRectangle=22
     IiCircle=23
     IiEllipse=24
     IiCylinder=32
     IiSphere=33
     IiPointCloud=35
```

```
       liBlob=50
       '_
       ENET1.IP="192.168.1.11"
       ENET1.RPORT=5001
       ENET1.LPORT=5001
       ENET1.OPEN 1
       CLR_RBUF ENET1
       DELAY 1
       '_
       '_
       PICKIT.ITF ENET1,CNX=0,WAIT=10 'Response wait time set to 10 seconds
       V1%=1 'Pose designation variable
       '_
     1 PICKIT.CHK
       IF PICKIT.STATUS=liCalibMode THEN 3 ELSE 99
     3 DELAY 0.5
S1     MOVE P,P[V1%],S=60%,A=3,T=0
       PICKIT.FCP
       IF PICKIT.STATUS=liStatusErr THEN 99 ELSE 7
     7 IF PICKIT.STATUS=liFCPOK THEN
       V1%=V1%+1
       ELSEIF PICKIT.STATUS=liFCPFail THEN
       V1%=V1%
       ENDIF
       IF V1%>5 THEN 99 ELSE 3
    99 END
```

## 6.3. Bin Picking JOB file

The following shows the entire example of the bin picking JOB file described in Chapter 4. Refer to Chapter 4 for the detailed description. Considering that depending on the type of the gripper or the characteristics of the work, other commands can be used to write a JOB file, refer to this for other applications.

**Program File Format Version: 1.6 MechType: 127(HA020-03) TotalAxis: 6 AuxAxis: 0**

```
'
_
'_Pick-it Mode
DIM IiStatusErr AS Integer
DIM IiRunMode AS Integer
DIM IiIdleMode AS Integer
DIM IiCalibMode AS Integer
'_Pick-it Status
DIM IiFCPOK AS Integer
DIM IiFCPFail AS Integer
DIM IiObjFound AS Integer
DIM IiNoObj AS Integer
DIM IiNoImgCap AS Integer
DIM IiCFGOK AS Integer
DIM IiCFGFail AS Integer
DIM IiSVSOK AS Integer
DIM IiSVSFail AS Integer
'_Pick-it Type
DIM IiSquare AS Integer
DIM IiRectangle AS Integer
DIM IiCircle AS Integer
DIM IiEllipse AS Integer
DIM IiCylinder AS Integer
DIM IiSphere AS Integer
DIM IiPointCloud AS Integer
DIM IiBlob AS Integer
'
_
IiStatusErr=-1
IiRunMode=0
IiIdleMode=1
IiCalibMode=2
'
_
IiFCPOK=10
IiFCPFail=11
IiObjFound=20
IiNoObj=21
IiNoImgCap=21
IiCFGOK=40
IiCFGFail=41
IiSVSOK=50
IiSVSFail=51
'
_
IiSquare=21
IiRectangle=22
IiCircle=23
IiEllipse=24
IiCylinder=32
```

```
        liSphere=33
        liPointCloud=35
        liBlob=50
        '
        'Ethernet setting
        ENET1.IP="192.168.1.11"
        ENET1.RPORT=5001
        ENET1.LPORT=5001
        ENET1.OPEN 1
        CLR_RBUF ENET1
        '
        'Pick-it setting
        PICKIT.ITF ENET1,CNX=1,WAIT=3
        PICKIT.CHK
        IF PICKIT.STATUS=liRunMode THEN 1 ELSE 99
      1 PICKIT.CFG SETUP=12,PROD=19
        PRINT #0,PICKIT.STATUS
        DELAY 0.5
        IF PICKIT.STATUS=liCFGOK THEN 11 ELSE 99
        '
        'First picking work
     11 PICKIT.LFO P1
        IF PICKIT.STATUS=liObjFound THEN 12 ELSE 99
     12 P2=P1
        P2.Z=P1.Z+300
S1      MOVE P,P2,S=50%,A=3,T=0 'Moves the workpiece upwards
        P2.Z=P1.Z
S2      MOVE P,P2,S=50%,A=3,T=0 'Workpiece picking position
        DELAY 0.5
        DO1=1 'Digital control of the gripper
        P2.Z=P1.Z+300 'Picks the workpiece and then moves vertically
S3      MOVE P,P3,S=50%,A=3,T=0 'Workpiece loading position
        DELAY 0.5
        DO1=0 'Digital control of the gripper
        '
        'Picking work yet to be performed
        IF PICKIT.REMAIN>0 THEN 21 ELSE 99
     21 FOR V1!=1 TO PICKIT.REMAIN STEP 1
        PICKIT.NXT P1 'Workpiece pose stored in the Pick-it memory
        P2=P1
        P2.Z=P1.Z+300
S4      MOVE P,P2,S=50%,A=3,T=0 'Moves the workpiece upwards
        P2.Z=P1.Z
S5      MOVE P,P2,S=50%,A=3,T=0 'Workpiece picking position
        DELAY 0.5
        DO1=1 'Digital control of the gripper
        P2.Z=P1.Z+300 'Picks the workpiece and moves vertically
S6      MOVE P,P3,S=50%,A=3,T=0 'Workpiece loading position
        DELAY 0.5
        DO1=0 'Digital control of the gripper
        NEXT 'Ending of the FOR statement
        '
     99 'Setting of the ending
S7      MOVE P,P4,S=50%,A=3,T=0 'Move to the pose
```

```
PICKIT.ITF ENET1,CNX=0,WAIT=3
ENET1.OPEN 0
END
```

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