Upon receipt of the product and prior to initial operation, read these instructions thoroughly, and retain for future reference.

**MOTOMAN INSTRUCTIONS**
- MOTOMAN-□□□ INSTRUCTIONS
- DX200 INSTRUCTIONS
- DX200 OPERATOR’S MANUAL (for each purpose)
- DX200 MAINTENANCE MANUAL

The DX200 operator’s manuals above correspond to specific usage. Be sure to use the appropriate manual.
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Printed in the United States of America

First Printing, 2015

Yaskawa America, Inc.
Motoman Robotics Division
100 Automation Way
Miamisburg, OH 45342
Phone: 937-847-6200

www.motoman.com
MANDATORY

- This manual explains MotoFit of the DX200 system. Read this manual carefully and be sure to understand its contents before handling the DX200.
- General items related to safety are listed in the Chapter 1: Safety of the DX200 Instructions. To ensure correct and safe operation, carefully read the DX200 Instructions before reading this manual.

CAUTION

- Some drawings in this manual are shown with the protective covers or shields removed for clarity. Be sure all covers and shields are replaced before operating this product.
- The drawings and photos in this manual are representative examples and differences may exist between them and the delivered product.
- YASKAWA may modify this model without notice when necessary due to product improvements, modifications, or changes in specifications. If such modification is made, the manual number will also be revised.
- If your copy of the manual is damaged or lost, contact a YASKAWA representative to order a new copy. The representatives are listed on the back cover. Be sure to tell the representative the manual number listed on the front cover.
- YASKAWA is not responsible for incidents arising from unauthorized modification of its products. Unauthorized modification voids your product’s warranty.
We suggest that you obtain and review a copy of the ANSI/RIA National Safety Standard for Industrial Robots and Robot Systems (ANSI/RIA R15.06-2012). You can obtain this document from the Robotic Industries Association (RIA) at the following address:

Robotic Industries Association
900 Victors Way
P.O. Box 3724
Ann Arbor, Michigan 48106
TEL: (734) 994-6088
FAX: (734) 994-3338
www.roboticsonline.com

Ultimately, well-trained personnel are the best safeguard against accidents and damage that can result from improper operation of the equipment. The customer is responsible for providing adequately trained personnel to operate, program, and maintain the equipment. NEVER ALLOW UNTRAINED PERSONNEL TO OPERATE, PROGRAM, OR REPAIR THE EQUIPMENT!

We recommend approved Yaskawa training courses for all personnel involved with the operation, programming, or repair of the equipment.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications.
Notes For Safe Operation

Read this manual carefully before installation, operation, maintenance, or inspection of the DX200.

In this manual, the Notes for Safe Operation are classified as “DANGER”, “WARNING”, “CAUTION”, “MANDATORY”, or “PROHIBITED”.

DANGER
Indicates an imminent hazardous situation which, if not avoided, could result in death or serious injury to personnel.

WARNING
Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury to personnel.

CAUTION
Indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury to personnel and damage to equipment. It may also be used to alert against unsafe practices.

MANDATORY
Always be sure to follow explicitly the items listed under this heading.

PROHIBITED
Must never be performed.

Even items described as “CAUTION” may result in a serious accident in some situations.
At any rate, be sure to follow these important items.

To ensure safe and efficient operation at all times, be sure to follow all instructions, even if not designated as “DANGER”, “WARNING” and “CAUTION”.
WARNING

• Before operating the manipulator, check that servo power is turned off when the emergency stop buttons on the front door of the DX100 and programing pendant are pressed. When the servo power is turned off, the SERVO ON LED on the programing pendant is turned off.

Injury or damage to machinery may result if the emergency stop circuit cannot stop the manipulator during an emergency. The manipulator should not be used if the emergency stop buttons do not function.

Figure 1: Emergency Stop Button

• Once the emergency stop button is released, clear the cell of all items which could interfere with the operation of the manipulator. Then turn the servo power ON.

Injury may result from unintentional or unexpected manipulator motion.

Figure 2: Release of Emergency Stop

• Observe the following precautions when performing teaching operations within the P-point maximum envelope of the manipulator:
  – Be sure to use a lockout device to the safeguarding when going inside. Also, display the sign that the operation is being performed inside the safeguarding and make sure no one closes the safeguarding.
  – View the manipulator from the front whenever possible.
  – Always follow the predetermined operating procedure.
  – Ensure that you have a safe place to retreat in case of emergency.

Improper or unintended manipulator operation may result in injury.

• Confirm that no person is present in the P-point maximum envelope of the manipulator and that you are in a safe location before:
  – Turning on the power for the DX200.
  – Moving the manipulator with the programming pendant.
  – Running the system in the check mode.
  – Performing automatic operations.

Injury may result if anyone enters the working envelope of the manipulator during operation. Always press an emergency stop button immediately if there are problems.

The emergency stop button is located on the right of the front door of the DX100 and programing pendant.
The MOTOMAN is the YASKAWA industrial robot product.

The MOTOMAN usually consists of the manipulator, the controller, the programming pendant, and supply cables.

In this manual, the equipment is designated as follows.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Manual Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>DX200 controller</td>
<td>DX200</td>
</tr>
<tr>
<td>DX200 programming pendant</td>
<td>Programming pendant</td>
</tr>
<tr>
<td>Cable between the manipulator and the controller</td>
<td>Manipulator cable</td>
</tr>
</tbody>
</table>
Descriptions of the programming pendant keys, buttons, and displays are shown as follows:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Manual Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programming Pendant</td>
<td>Character Keys /Symbol Keys: The keys which have characters or its symbol printed on them are denoted with [ ]. ex. [ENTER]</td>
</tr>
<tr>
<td>Axis Keys /Numeric Keys</td>
<td>[Axis Key] and [Numeric Key] are generic names for the keys for axis operation and number input.</td>
</tr>
<tr>
<td>Keys pressed simultaneously</td>
<td>When two keys are to be pressed simultaneously, the keys are shown with a “+” sign between them. ex. [SHIFT]+[COORD]</td>
</tr>
<tr>
<td>Displays</td>
<td>Displays: The menu displayed in the programming pendant is denoted with { }. ex. {JOB}</td>
</tr>
</tbody>
</table>

**Description of the Operation Procedure**

In the explanation of the operation procedure, the expression “Select • • • ” means that the cursor is moved to the object item and the SELECT key is pressed, or that the item is directly selected by touching the screen.

**Registered Trademark**

In this manual, names of companies, corporations, or products are trademarks, registered trademarks, or brand names for each company or corporation. The indications of (R) and ™ are omitted.
Customer Support Information

If you need assistance with any aspect of your DX200 MotoFit system, please contact Motoman Customer Support at the following 24-hour telephone number:

(937) 847-3200

For routine technical inquiries, you can also contact Motoman Customer Support at the following e-mail address:

techsupport@motoman.com

When using e-mail to contact Motoman Customer Support, please provide a detailed description of your issue, along with complete contact information. Please allow approximately 24 to 36 hours for a response to your inquiry.

Please use e-mail for routine inquiries only. If you have an urgent or emergency need for service, replacement parts, or information, you must contact Motoman Customer Support at the telephone number shown above.

Please have the following information ready before you call Customer Support:

- System: DX200 MotoFit
- Robots: ___________________________
- Primary Application: ___________________________
- Controller: DX200
- Software Version: Access this information on the Programming Pendant’s LCD display screen by selecting {MAIN MENU} - {SYSTEM INFO} - {VERSION}
- Robot Serial Number: Located on the robot data plate
- Robot Sales Order Number: Located on the DX200 controller data plate
# Table of Contents

1 MotoFit Function ............................................................................................................................. 1-1  
   1.1 Overview of MotoFit Function ............................................................................................ 1-1  
   1.2 System Configuration of MotoFit Function ........................................................................ 1-1  
2 Usage Example of MotoFit Function.......................................................................................... 2-1  
   2.1 Operation Example ............................................................................................................ 2-1  
   2.2 Job Examples .................................................................................................................... 2-4  
   2.3 Setting in Force Condition File .......................................................................................... 2-5  
   2.4 Setting Images of Parameters (Threshold Data) ............................................................... 2-6  
   2.5 Force Sense Basic Command ........................................................................................... 2-7  
3 Commands for the MotoFit Function.......................................................................................... 3-1  
   3.1 IMPOFF ............................................................................................................................. 3-1  
   3.2 TOUCH .............................................................................................................................. 3-2  
   3.3 FIT ..................................................................................................................................... 3-4  
   3.4 INSERT............................................................................................................................... 3-6  
   3.5 IMPON (Macro Instruction) ............................................................................................... 3-9  
   3.6 FREF (Macro Instruction) .................................................. ................................................................ 3-10  
   3.7 FDET (Macro Instruction) ................................................................................................. 3-12  
   3.8 IMPOFF (Macro Instruction) ............................................................................................ 3-17  
4 Registration of Command ........................................................................................................... 4-1  
   4.1 IMPOFF ............................................................................................................................. 4-2  
   4.2 TOUCH .............................................................................................................................. 4-3  
   4.3 FIT ..................................................................................................................................... 4-4  
   4.4 INSERT............................................................................................................................... 4-5  
   4.5 IMPON (Macro Instruction) ............................................................................................... 4-6  
   4.6 FREF (Macro Instruction) ................................................................................................. 4-7  
   4.7 FDET (Macro Instruction) ................................................................................................. 4-8  
   4.8 IMPOFF (Macro Instruction) ............................................................................................ 4-9
5 Alarm and Status Output Signal

5.1 Alarm List

5.2 System Output

5.3 General Output

6 Remarks

6.1 Operation When the MotoFit Function is Working

6.2 Usage of "TOUCH", "FIT", and "INSERT"

6.3 Operation while a TIMER or WAIT Command is Executed

6.4 Using the MotoFit Function in a Test Operation

6.5 Using the MotoFit Function during the Machine-Lock Operation

6.6 Interruption of Operation While the MotoFit Function Executes

6.7 Step Execution

6.8 Restrictions of Usage Environment

6.9 Holding of Workpiece by Hand

6.10 JOB Operation with Multiple Control Groups

6.11 Payload of the Robot

6.12 Maximum load of the force sensor

6.13 Restriction of Fit Direction

6.14 Sensor Cable Outfitting
1 MotoFit Function

1.1 Overview of MotoFit Function

The MotoFit function\(^1\) achieves a precision fit by a robot by detecting external forces acted on the tool coordinate home position with the 6-axis force sensor to correct for the manipulator position. The 6-axis force sensor, which can detect three translational forces and three axial moments, is installed at the manipulator’s tip in order to detect external forces in the job involving “Touch”.

Normal control is a position control which retains position even when external forces are applied. The MotoFit function, on the other hand, achieves a precision fit, with a force control, correcting position to match the force acted on the tool coordinate home position, based on the force feedback.

The MotoFit function incorporates the following four special commands suitable for the positioning of precision parts for a clearance from approx. 10 \(\mu\)m to 100 \(\mu\)m.

- \(\text{SKILLSND} \ “\text{TCH: } \ast \ast \ast “ \) : TOUCH (TOUCH)
- \(\text{SKILLSND} “\text{FIT: } \ast \ast \ast “ \) : Search (FIT)
- \(\text{SKILLSND} “\text{INS: } \ast \ast \ast “ \) : Insertion (INSERT)
- \(\text{SKILLSND} “\text{IOF} “ \) : Finish Force Control (IMPOFF)

Besides, in order to adapt to the hardness of various kinds of workpiece, such as plastic, wood, and metal, the force condition file, in which optimal parameters can be set according to the hardness of a workpiece, is prepared. Use the MotoFit Function Engineering Support Tool for the settings in the force condition file. (Refer to DX200 MotoFit Function Engineering Support Tool.)

Besides the above command the four force sense basic commands. (Refer to section 2.5 “Force Sense Basic Command”)
- \(\text{IMPON} \) (Macro Instruction)
- \(\text{FREF} \) (Macro Instruction)
- \(\text{FDET} \) (Macro Instruction)
- \(\text{IMPOFF} \) (Macro Instruction)

1.2 System Configuration of MotoFit Function

MotoFit Function operates in the system configuration with DX200 equipped with MotoFit power supply box and the manipulator equipped with the 6-axis force sensor on the tip of it.

Install the 6-axis force sensor and wire the sensor cables according to DX200 MAINTENANCE MANUAL for MotoFit Function before use.

---

\(^1\) For the MotoFit Function, optional functions are prepared, which is openly developed utilizing MotoPlus. When using the optional functions developed openly, refer to “Force Control” in DX200 OPTIONS INSTRUCTIONS Programmer’s Manual for New Language Environment MotoPlus (165981-1CD).
2 Usage Example of MotoFit Function

Using a normal position control only is insufficient to retain accuracy in repetitive positioning. Therefore, it is difficult to assemble precision parts for a clearance from 10 μm to 100 μm.

The following shows the instructions to use the MotoFit function in such an occasion.

2.1 Operation Example

The following shows an example of operation in which a workpiece with a key groove is fit to its mating part:

1. Holds a workpiece and moves to the waiting position.
2. With the workpiece held, moves to the job start point.
3. Starts the force control by the TOUCH command to make the workpiece touch the mating part.
4. Waits until the workpiece touches the mating part and the job completion signal is output.
2. Usage Example of MotoFit Function

2.1 Operation Example

(5) Executes the hole search operation by the FIT command.

(6) Waits until the hole search operation becomes successful (or failed and time-out) and the job completion signal is output.

(7) Executes the positioning pin search operation by the FIT command.

(8) Waits until the positioning pin search operation becomes successful (or failed and time-out) and the job completion signal is output.

(9) Executes the workpiece insertion operation by the INSERT command.

Insertion is complete.
2.1 Operation Example

(10) Waits until the workpiece insertion operation becomes successful (or failed and time-out) and the job completion signal is output.

(11) The force control ends and the normal operation by the position control is restored.

(12) Releases the workpiece and retracts.
### 2.2 Job Examples

<table>
<thead>
<tr>
<th>No.</th>
<th>Operation</th>
<th>Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Moves to waiting position.</td>
<td>MOVJ VJ=50.0</td>
</tr>
<tr>
<td>2</td>
<td>Moves to job start point.</td>
<td>MOVL V=50.0</td>
</tr>
<tr>
<td>3</td>
<td>Makes the workpiece touch the mating part.</td>
<td>SKILLSND &quot;TCH:1:10:40:10:10:100:10&quot;</td>
</tr>
<tr>
<td>4</td>
<td>Wait until the FIT command (TOUCH) execution completion signal (general output signal No.: 11273) is output.</td>
<td>WAIT OT#(1012)=ON</td>
</tr>
<tr>
<td>5</td>
<td>Hole search operation</td>
<td>SKILLSND &quot;FIT:1:70:5:2:200:300:2:200&quot;</td>
</tr>
<tr>
<td>6</td>
<td>Wait until the FIT command (FIT) success signal (general output signal No.: 11271) is output.</td>
<td>WAIT SOUT#(1010)=ON</td>
</tr>
<tr>
<td>7</td>
<td>Positioning pin search operation</td>
<td>SKILLSND &quot;FIT:1:120:50:1:20:600:4:100&quot;</td>
</tr>
<tr>
<td>8</td>
<td>Wait until the FIT command (FIT) success signal (general output signal No.: 11271) is output.</td>
<td>WAIT OT#(1010)=ON</td>
</tr>
<tr>
<td>9</td>
<td>Workpiece insertion operation</td>
<td>SKILLSND &quot;INS:1:300:180:210:1:8:70:2:20&quot;</td>
</tr>
<tr>
<td>10</td>
<td>Wait until the FIT command (INSERT) execution completion signal (general output signal No.: 11275) is output.</td>
<td>WAIT OT#(1014)=ON</td>
</tr>
<tr>
<td>11</td>
<td>Force control ends.</td>
<td>SKILLSND &quot;IOF&quot;</td>
</tr>
<tr>
<td>12</td>
<td>Releases the workpiece.</td>
<td>DOUT OT#(1) ON</td>
</tr>
</tbody>
</table>

1 "No." corresponds to the operation step No. in section 2.1 "Operation Example" on page 2-1.
2.3 Setting in Force Condition File

Refer to the Instruction Manual for DX200 MotoFit Function Engineering Support Tool. Creation, editing, and deletion of the force condition file are available only by using the DX200 MotoFit Function Engineering Support Tool.

Fig. 2-1: Force Condition File Setting Display on MotoFit Function Engineering Support Tool
2.4 Setting Images of Parameters (Threshold Data)

The thresholds (1 to 6 in the table below) related with travel distance and insertion length among the parameters in the TOUCH, FIT, and INSERT commands have to be tuned according to the positioning error at the job start point and/or the dimensions of the mating part.

<table>
<thead>
<tr>
<th>No.</th>
<th>Operation</th>
<th>Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Makes workpiece touch.</td>
<td>SKILLSND &quot;TCH:1:10:3:1&quot;</td>
</tr>
<tr>
<td>5</td>
<td>Hole search operation</td>
<td>SKILLSND &quot;FIT:1:10:3:1:12:200:0:2&quot;</td>
</tr>
<tr>
<td>7</td>
<td>Positioning pin search operation</td>
<td>SKILLSND &quot;FIT:1:10:3:2:2:250:4:3&quot;</td>
</tr>
<tr>
<td>9</td>
<td>Workpiece insertion operation</td>
<td>SKILLSND &quot;INS:1:20:19:20:1:3:200:0:10&quot;</td>
</tr>
</tbody>
</table>

1 "No." corresponds to the operation step No. in section 2.1 "Operation Example" on page 2-1.

The following is the guidance for settings.

1. Push length threshold
   \[ L_{\text{push}} = B + C + dA \]
2. Prospective touch length
   \[ L_{\text{approach}} = A \]
3. Insertion length threshold
   \[ L_{\text{ins}} = B + C + dA \]
4. Insertion length threshold
   \[ L_{\text{ins}} = B + C + dA \]
5. Insertion length threshold
   \[ L_{\text{ins1}} = B + D - dA \]
6. Insertion length threshold
   \[ L_{\text{ins2}} = B + D + dA + sl \]

\( sl \): Slippage length when workpiece slips from hand at insertion

Refer to chapter 3 “Commands for the MotoFit Function” for the setting values other than thresholds.
2.5 Force Sense Basic Command

Although TOUCH, FIT, and INSERT are the command packaging multiple operations due to precision interdigitiation, the force sensor basic command is the command targeting relatively simple work (e.g. pressing with constant force and stops the operation when detecting force over a specified force, etc.). The function outline for each command is shown in Table 2-1. For details of the command parameters, refer to chapter 3 "Commands for the MotoFit Function" and chapter 4 "Registration of Command". In addition, these commands are supplied as macro commands.

Table 2-1: Function Outline for Each Command

<table>
<thead>
<tr>
<th>Name</th>
<th>IMPON</th>
<th>IMPOFF</th>
<th>FDET</th>
<th>FREF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>Reset the force sensor value to zero, and then turn the force control ON. To keep the force balanced, move according to external forces.</td>
<td>Returns to position control from force control.</td>
<td>When force and impulse exceeds a threshold, the signal (general output) is turned ON.</td>
<td>Press the robot arm head force sensor tool against the workpiece with the specified force.</td>
</tr>
</tbody>
</table>

Figure
This shows an example of work for applying tape to a plate by moving while pressing the tape down with a constant force. The figure below shows an example where a force sensor value is detected from a protrusion under the tape during movement, which stops the operation. An example JOB is shown below. Monitor the X direction force by the FDET command, and if the robot arm head force sensor tool contacts a protrusion, the force sensor detects the force and the general output is turned ON., and then the robot arm head force sensor tool stops.

**Fig. 2-2: Example of Work for Applying Tape to a Plate**

```
NOP
IMPON           Force control ON
FREF           Pressing in Z direction
FDET          X direction force monitoring
MOVL V=80 UNTIL IN#(991)=ON  Moving in the X direction (stops when detecting the force by FDET)
IMPOFF
END
```
The MotoFit function uses the following four special commands suitable for the fitting precision parts for a clearance from 10 μm to 100 μm.

- SKILLSND "IOF" : Finish Force Control (IMPOFF)
- SKILLSND "TCH: • • • " : TOUCH (TOUCH)
- SKILLSND "FIT: • • • " : Search (FIT)
- SKILLSND "INS: • • • " : Insertion (INSERT)

Define an intended command by directly inputting text in the command area of SKILLSND command.

Besides the above command the four force sense basic commands.

- IMPON (Macro Instruction)
- FREF (Macro Instruction)
- FDET (Macro Instruction)
- IMPOFF (Macro Instruction)

3.1 IMPOFF

"IMPOFF" is a command to end the MotoFit function and restore the position control. The force control becomes invalid by this command.

Descriptions input to the command area shall be "IOF" as shown below.

SKILLSND "IOF"
3.2 TOUCH

"TOUCH" is a command to make a workpiece touch its mating part. The TOUCH command makes the force control valid to let the manipulator's tip follow the external force.

"TCH" shall be input for the command as shown below, and parameters shall follow after that.

```
```

① Force condition file number (FileNum)
   Sets the number of the force control condition file.
   Setting range: 1 to 24

② Touch force threshold (Fapproach)
   Sets the touch force threshold. The touch force represents the force acted when a workpiece touches its mating part. When a force exceeds the touch force threshold acts, it is judged that "Touch" has occurred.
   Setting range: 0 to 999, Unit: [0.1 N]

③ Approach speed (Vapproach)
   Sets the approach speed.
   The approach speed is the speed from the command execution to the judgement of "Touch" occurrence.
   Setting range: 0 to 500, Unit: [0.1 mm/s]

④ Push force command value (Fpush)
   Sets the command value to push a workpiece. This is the command value of the touch force after occurrence of "Touch" is judged.
   Setting range: 0 to 999, Unit: [0.1 N]

⑤ Push length threshold (Lpush)
   Sets the push length threshold. The push length is the travel distance from the point where occurrence of "Touch" is judged. The job completion signal is output when the push length exceeds the push length threshold.
   Setting range: 0 to 999, Unit: [0.1 mm]

⑥ Prospective touch length (Lapproach)
   Sets the prospective touch length. The prospective touch length is the distance from the job start point to the point where a workpiece touches its mating part.
   Setting range: 0 to 500, Unit: [0.1 mm]

⑦ After-touch time-out time (Tpush)
   Sets the after-touch time-out time. The job completion signal is forcibly output when the after-touch time-out time has expired after starting of "TOUCH".
   Setting range: 0 to 999, Unit: [0.1 s]
### Table 3-2: Parameter List of TOUCH Command

<table>
<thead>
<tr>
<th>No.</th>
<th>Parameter Name</th>
<th>Abbreviated form</th>
<th>Setting range</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Force condition file number</td>
<td>FileNum</td>
<td>1 to 24</td>
<td>—</td>
</tr>
<tr>
<td>2</td>
<td>Touch force threshold</td>
<td>Fapproach</td>
<td>0 to 999</td>
<td>0.1 N</td>
</tr>
<tr>
<td>3</td>
<td>Approach speed</td>
<td>Vapproach</td>
<td>0 to 500</td>
<td>0.1 mm/s</td>
</tr>
<tr>
<td>4</td>
<td>Push force command value</td>
<td>Fpush</td>
<td>0 to 999</td>
<td>0.1 N</td>
</tr>
<tr>
<td>5</td>
<td>Push length threshold</td>
<td>Lpush</td>
<td>0 to 999</td>
<td>0.1 mm</td>
</tr>
<tr>
<td>6</td>
<td>Prospective touch length</td>
<td>Lapprach</td>
<td>0 to 500</td>
<td>0.1 mm</td>
</tr>
<tr>
<td>7</td>
<td>After-touch time-out time</td>
<td>Tpush</td>
<td>0 to 999</td>
<td>0.1 s</td>
</tr>
</tbody>
</table>
3.3 FIT

"FIT" is a command to execute the search operation, vibrating the tool's tip in translational directions or rotational directions. The FIT command makes the force control valid to let the manipulator's tip follow the external force.

Normally, this command is used under the condition a workpiece is in touch with its target part (under the status when "TOUCH" has completed). Execute this command only while the force control continues after TOUCH has completed. If this command is executed in other status, Alarm 8102 "FIT command execution step error" occurs.

"FIT" shall be input for the command as shown below, and parameters shall follow after that.

```
```

1. Force condition file number (FileNum)
   Sets the number of the force control condition file.
   Setting range: 1 to 24

2. Force command value (Fpush)
   Sets the force command value. This is the command value of the force in the manipulator's advancement direction.
   Setting range: 0 to 999, Unit: [0.1 N]

3. Insertion length threshold (Lins)
   Sets the insertion length threshold.
   The insertion length is the travel distance from the point where occurrence of "Touch" is judged in TOUCH command. The job completion signal is output when the insertion length exceeds the insertion length threshold.
   Setting range: 0 to 999, Unit: [0.1 mm]

4. Search operation pattern (Ptn_search)
   Sets the search operation pattern.
   "0: XYZ" executes a reciprocating search operation in one of X-axis, Y-axis, and Z-axis directions (specified in 7 later).
   "1: ROTATE" executes a rotating search operation in one of X-axis, Y-axis, and Z-axis rotational directions.
   "2: OMNI" executes a reciprocating search operation, changing its search direction by a certain angle.
   Setting range: 0 to 2 (0: XYZ, 1: ROTATE, 2: OMNI)

5. Search force command value (Fsearch) or Search moment command value (Msearch)
   Sets the command value of the force (or moment) in the search direction.

   <When "0: XYZ" or "2: OMNI" is set in the above 4>
   Setting range: 0 to 999, Unit: [0.1 N]

   <When "1: ROTATE" is set in the above 4>
   Setting range: 0 to 99, Unit: [0.1 Nm]
Search vibration cycle (Cycle_search)
Sets the vibration cycle of the search operation.
Setting range: 2 to 999, Unit: [ms]

Search axial direction designation (Dir_search)
Selects the axial direction of the search operation.
<When "0: XYZ" or "2: OMNI" is set in the above>
Set the direction to start the vibration of the search operation.
<When "2: ROTATE" is set in the above>
Set the axis of the rotational search operation.
E.g.) Set "4" for the Z-axial rotation.
Setting range: 0 to 5 (0: X+, 1: X-, 2: Y+, 3: Y-, 4: Z+, 5: Z-)

Search operation time (Tsearch)
Sets the search operation execution time.
Setting range: 0 to 999, Unit: [0.1 s]

Table 3-3: FIT Command List

<table>
<thead>
<tr>
<th>No.</th>
<th>Parameter Name</th>
<th>Abbreviated Form</th>
<th>Setting Range</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Force condition file number</td>
<td>FileNum</td>
<td>1 to 24</td>
<td>—</td>
</tr>
<tr>
<td>2</td>
<td>Force command value</td>
<td>Fpush</td>
<td>0 to 999</td>
<td>0.1 N</td>
</tr>
<tr>
<td>3</td>
<td>Insertion length threshold</td>
<td>Lins</td>
<td>0 to 999</td>
<td>0.1 mm</td>
</tr>
<tr>
<td>4</td>
<td>Search operation pattern</td>
<td>Ptn_search</td>
<td>0 to 2</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0 : XYZ, 1 : ROTATE, 2 : OMNI</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Search force command value</td>
<td>Fsearch</td>
<td>0 to 999</td>
<td>0.1 N</td>
</tr>
<tr>
<td>6</td>
<td>Search moment command value</td>
<td>Msearch</td>
<td>0 to 99</td>
<td>0.1 Nm</td>
</tr>
<tr>
<td>7</td>
<td>Search vibration cycle</td>
<td>Cycle_search</td>
<td>2 to 999</td>
<td>ms</td>
</tr>
<tr>
<td>8</td>
<td>Search axial direction designation</td>
<td>Dir_search</td>
<td>0 to 5</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0 : X+, 1 : X-, 2 : Y+, 3 : Y-, 4 : Z+, 5 : Z-</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Search operation time</td>
<td>Tsearch</td>
<td>0 to 999</td>
<td>0.1 s</td>
</tr>
</tbody>
</table>
3.4 INSERT

"INSERT" is a command to insert a workpiece in the designated direction. The INSERT command makes the force control valid to let the manipulator's tip follow the external force.

Normally, this command is used when the fit target (hole) has matched the fit workpiece position (e.g. under FIT complete status). Execute this command only while the force control continues after TOUCH has completed. If this command is executed in other status, Alarm 8102 "FIT command execution step error" occurs.

"INS" shall be input for the command as shown below, and parameters shall follow after that.

```
SKILLSND "INS : 1 : 2 : 3 : 4 : 5 : 6 : 7 : 8 : 9"
```

1. Force condition file number (FileNum)
   Sets the number of the force control condition file.
   Setting range: 1 to 24

2. Force command value (Fpush)
   Sets the force command value. This is the command value of the force in the manipulator's advancement direction.
   Setting range: 0 to 999 (Upper limit), Unit: [0.1 N]

3. Insertion length threshold (Lins1)
   Sets the insertion length threshold. In the INSERT command, "Lins1" becomes the lower limit of the insertion length threshold.
   The insertion length represents the travel distance from the point at which occurrence of "Touch" is judged in the TOUCH command. The job completion signal is output as soon as the insertion length exceeds the insertion length threshold.
   In combination with 4 mentioned later, set this value to ensure the following correlation:
   \[ Lins1 < (\text{Insertion length command}) < Lins2 \]
   Setting range: 0 to 999, Unit: [0.1 mm]

4. Insertion length threshold (Lins2)
   Sets the insertion length threshold. In the INSERT command, "Lins2" becomes the upper limit of the insertion length threshold.
   The insertion length represents the travel distance from the point at which occurrence of "Touch" is judged in the TOUCH command. The job completion signal is output when the insertion length exceeds the insertion length threshold.
   In combination with the above 3, set this value to ensure the following correlation:
   \[ Lins1 < (\text{Insertion length command}) < Lins2 \]
   Setting range: 0 to 999, Unit: [0.1 mm]
3.4 INSERT

5 Unchoke operation designation (Ptn_unchoke)

Designates the unchoke operation. This designation selects whether or not to execute the search operation when the robot's operation speed decreases during the execution of the INSERT command. The search operation performed in such a case is called as the unchoke operation.

<When set to "0">

When the operation speed has decreased, the operation completion signal is output without executing the unchoke operation.

<When set to "1">

When the operation speed has decreased, the unchoke operation is executed. The search operation pattern is the same as in the case when "0: XYZ" is set for "3.4 FIT ④".

<When set to "2">

When the operation speed has decreased, the unchoke operation is executed. The search operation pattern is the same as in the case when "2: OMNI" is set for "3.4 FIT ④".

Setting range: 0 to 2

6 Unchoke operation force command value (F_unchoke)

Sets the force command value in the search direction for the unchoke operation when "1" or "2" is set in the former ⑤.\(^1\)

Setting range: 0 to 999, Unit: [0.1 N]

7 Unchoke operation force command cycle (Ts_unchoke)

Sets the vibration cycle of the search operation for the unchoke operation when "1" or "2" is set in the former ⑤.\(^1\)

Setting range: 2 to 999, Unit: [ms]

8 Unchoke operation start direction designation (Dir_unchoke)

Selects the axial direction of the search operation for the unchoke operation when "1" or "2" is set in the former ⑤. Set the direction in which the search operation is to start.\(^1\)

Setting range: 0 to 5 (0: X+, 1: X-, 2: Y+, 3: Y-, 4: Z+, 5: Z-)

9 Unchoke operation time (Tins)

Sets the search operation execution time in the unchoke operation when "1" or "2" is set in the former ⑤.\(^1\)

Setting range: 0 to 999, Unit: [0.1 s]

---

\(^1\) When 0 is set in ⑤, input any values within the range in ⑤ to ⑨. It does not affect the operation.
### Table 3-4: INSERT Command List

<table>
<thead>
<tr>
<th>No.</th>
<th>Parameter Name</th>
<th>Abbreviated Form</th>
<th>Setting Range</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Force condition file number</td>
<td>FileNum</td>
<td>1 to 24</td>
<td>—</td>
</tr>
<tr>
<td>2</td>
<td>Force command value</td>
<td>Fpush</td>
<td>0 to 999</td>
<td>0.1 N</td>
</tr>
<tr>
<td>3</td>
<td>Insertion length threshold 1</td>
<td>Lins1</td>
<td>0 to 999</td>
<td>0.1 mm</td>
</tr>
<tr>
<td>4</td>
<td>Insertion length threshold 2</td>
<td>Lins2</td>
<td>0 to 999</td>
<td>0.1 mm</td>
</tr>
<tr>
<td>5</td>
<td>Unchoke operation designation 0: Invalid, 1: XYZ, 2: OMNI</td>
<td>Ptn_unchoke</td>
<td>0 to 2</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0: No unchoke operation 1: Equivalent to &quot;XYZ&quot; for FIT command 2: Equivalent to &quot;OMNI&quot; for FIT command</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Unchoke operation force command amplitude</td>
<td>F_unchoke</td>
<td>0 to 999</td>
<td>0.1 N</td>
</tr>
<tr>
<td>7</td>
<td>Unchoke operation force command cycle</td>
<td>Ts_unchoke</td>
<td>2 to 999</td>
<td>ms</td>
</tr>
<tr>
<td>8</td>
<td>Unchoke operation start direction designation</td>
<td>Dir_unchoke</td>
<td>0 to 5</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0: X+, 1: X-, 2: Y+, 3: Y-, 4: Z+, 5: Z-</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Unchoke operation time</td>
<td>Tins</td>
<td>0 to 999</td>
<td>0.1 s</td>
</tr>
</tbody>
</table>
3.5 IMPON (Macro Instruction)

IMPON is a command that resets the force sensor value to zero and sets the force control state.
In the force control state, to keep the force balanced, the robot moves according to external forces.
After setting the force control state, the cursor moves to the next line.
This command is a macro instruction. If the robot which sets the force control state is R1, select IMPON-R1 from [COMMAND LIST], and select IMPON-R2 if the robot is R2.
Also, set the following parameters on the macro parameter setting window when inputting the command.

![Argument Setting](image)

1. **FILE_NO**
   Specify the force condition file number.
   Setting range: 1 to 24

2. **FORCE-CONTROL**
   This is the option that disables force control. If detecting force by starting only the measuring of force sensor in position control condition, set 1.
   Setting range: 0 to 1 (0: Enable, 1: Disable)

3. **OFFSET**
   This is the option that resets the force sensor value to zero.
   Although the force sensor value is normally set to 0, setting the value to 1 enables only the setting change of the force condition and the force control disable option.

Table 3-5: Parameter List of IMPON

<table>
<thead>
<tr>
<th>No.</th>
<th>Parameter Name</th>
<th>Abbreviated Form</th>
<th>Setting Range</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Force condition file number</td>
<td>FILE_NO</td>
<td>1 to 24</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Force control enable/</td>
<td>FORCE-CONTROL</td>
<td>0 to 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Force control disable</td>
<td></td>
<td>0: Enable</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1: Disable</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Force control</td>
<td>OFFSET</td>
<td>0 to 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0: Enable</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1: Disable</td>
<td></td>
</tr>
</tbody>
</table>
3.6 FREF (Macro Instruction)

FREF is a command that outputs the force command value to an arbitrary direction. This command operates only in a state where force control is continuing under another IMPON command, and an alarm 8012 (IMPON unexecuted error) occurs if FREF is executed in another state. Also, the force coordinate system is based on the definition of IMPON command force control.

The force command value is held until the force control stops by executing IMPOFF command or emergency stop. If a time-out error set by "TIMEOUT" that is a parameter of FREF is caused or "UNTIL" that is a parameter of FREF is enabled and a force is detected by FDET command, next instruction of the job is executed. The force control is continued by FREF command. If FREF that has command value different from previous one is set next line of the job, the force can be changed by "TIMEOUT" or FDET or can be stopped.

This command is macro instruction. If the target robot is R1, select FREF-R1 from [COMMAND LIST], and select FREF-R2 if the robot is R2. Also, set the following parameters on the macro parameter setting window when inputting the command.

<table>
<thead>
<tr>
<th>ARGUMENT SETTING</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>FREF-X</td>
<td>0</td>
<td>①</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FREF-Y</td>
<td>0</td>
<td>②</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FREF-Z</td>
<td>-10</td>
<td>③</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FREF-RX</td>
<td>0</td>
<td>④</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FREF-RY</td>
<td>0</td>
<td>⑤</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FREF-RZ</td>
<td>0</td>
<td>⑥</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UNTIL</td>
<td>1</td>
<td>⑦</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIMEOUT</td>
<td>5000</td>
<td>⑧</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

① FREF-X
Set the force command value for the X direction.
Setting range: -200 to 200, Unit: [N]

② FREF-Y
Set the force command value for the Y direction.
Setting range: -200 to 200, Unit: [N]

③ FREF-Z
Set the force command value for the Z direction.
Setting range: -200 to 200, Unit: [N]

④ FREF-RX
Set the force command value for the RX direction.
Setting range: -3000 to 3000, Unit: [0.01 N·m]
3 Commands for the MotoFit Function
3.6 FREF (Macro Instruction)

5 FREF-RY
Set the force command value for the RY direction.
Setting range: -3000 to 3000, Unit: [0.01 N m]

6 FREF-RZ
Set the force command value for the RZ direction.
Setting range: -3000 to 3000, Unit: [0.01 N m]

7 UNTIL
Specify enable or disable for UNTIL.
If UNTIL is enabled and a force is detected by FDET command, next instruction of the job is executed. The force control is continued by FREF command.
Setting range: 0 to 1 (0: Disable, 1: Enable)

8 TIMEOUT
Specify the timeout error check time [ms] for continuing the force command. After the timeout error check time elapses, next instruction of the job is executed. The force control is continued by FREF command.
Setting range: 0 to 2147483647, Unit: [ms]

Table 3-6: Parameter List of FREF

<table>
<thead>
<tr>
<th>No.</th>
<th>Parameter Name</th>
<th>Abbreviated Form</th>
<th>Setting Range</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Force command value for the X direction</td>
<td>FREF-X</td>
<td>-200 - 200</td>
<td>N</td>
</tr>
<tr>
<td>2</td>
<td>Force command value for the Y direction</td>
<td>FREF-Y</td>
<td>-200 - 200</td>
<td>N</td>
</tr>
<tr>
<td>3</td>
<td>Force command value for the Z direction</td>
<td>FREF-Z</td>
<td>-200 - 200</td>
<td>N</td>
</tr>
<tr>
<td>4</td>
<td>Force command value for the RX direction</td>
<td>FREF-RX</td>
<td>-3000 - 3000</td>
<td>N m</td>
</tr>
<tr>
<td>5</td>
<td>Force command value for the RY direction</td>
<td>FREF-RY</td>
<td>-3000 - 3000</td>
<td>N m</td>
</tr>
<tr>
<td>6</td>
<td>Force command value for the RZ direction</td>
<td>FREF-RZ</td>
<td>-3000 - 3000</td>
<td>N m</td>
</tr>
<tr>
<td>7</td>
<td>UNTIL enable or disable specification</td>
<td>UNTIL</td>
<td>0 - 1</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>Timeout error check time</td>
<td>TIMEOUT</td>
<td>0 - 2147483647</td>
<td>ms</td>
</tr>
</tbody>
</table>
3.7 FDET (Macro Instruction)

FDET is a command that monitors force and impulse and detects that the specified threshold is exceeded. When detected, the general output is turned ON. The output destination is R1: OUT#0991 and R2: OUT#0992. This command operates only in a state where force control is continuing under another IMPON command, and an alarm 8012 (IMPON unexecuted error) occurs if FREF is executed in another state. Also, the force coordinate system is based on the definition of the continuing force control.

To detect force, it is necessary to separately set the detection judgment time. It is judged as detection when the force over threshold continues during the detection judgment time.

Force and impulse are detected in FDET - FDET or FDET - IMPOFF. Impulse continues to be added up during detection.

This command is macro instruction. If the target robot is R1, select FDET-R1 from [COMMAND LIST], and select FDET-R2 if the robot is R2. Also, set the following parameters on the macro parameter setting window when inputting the command.

<table>
<thead>
<tr>
<th>ARGUMENT SETTING</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>METHOD</td>
<td>1</td>
</tr>
<tr>
<td>THRESHOLD-XHIGH</td>
<td>0</td>
</tr>
<tr>
<td>THRESHOLD-XLOW</td>
<td>0</td>
</tr>
<tr>
<td>THRESHOLD-YHIGH</td>
<td>10</td>
</tr>
<tr>
<td>THRESHOLD-YLOW</td>
<td>-10</td>
</tr>
<tr>
<td>THRESHOLD-ZHIGH</td>
<td>0</td>
</tr>
<tr>
<td>THRESHOLD-ZLOW</td>
<td>0</td>
</tr>
<tr>
<td>THRESHOLD-DXZHIGH</td>
<td>0</td>
</tr>
<tr>
<td>THRESHOLD-DXZLOW</td>
<td>0</td>
</tr>
<tr>
<td>TIME</td>
<td>500</td>
</tr>
</tbody>
</table>

1. **METHOD**
   - Set the detection method.
   - Setting range: 0 to 2
     - (0: Disabled, 1: Force detection, 2: Impulse detection)

   **<When Method=1 for 1>**

2. **THRESHOLD-XHIGH**
   - Set the force detection threshold maximum value for X direction. If the value is 0, it becomes disabled.
   - Setting range: -2147483647 to 2147483647, Unit: [N]

3. **THRESHOLD-XLOW**
   - Set the force detection threshold minimum value for X direction. If the value is 0, it becomes disabled.
   - Setting range: -2147483647 to 2147483647, Unit: [N]
3 Commands for the MotoFit Function
3.7 FDET (Macro Instruction)

4 THRESHOLD-YHIGH
Set the force detection threshold maximum value for Y direction. If the value is 0, it becomes disabled.
Setting range: -2147483647 to 2147483647, Unit: [N]

5 THRESHOLD-YLOW
Set the force detection threshold minimum value for Y direction. If the value is 0, it becomes disabled.
Setting range: -2147483647 to 2147483647, Unit: [N]

6 THRESHOLD-ZHIGH
Set the force detection threshold maximum value for Z direction. If the value is 0, it becomes disabled.
Setting range: -2147483647 to 2147483647, Unit: [N]

7 THRESHOLD-ZLOW
Set the force detection threshold minimum value for Z direction. If the value is 0, it becomes disabled.
Setting range: -2147483647 to 2147483647, Unit: [N]

8 THRESHOLD-XYZHIGH
Set the force detection threshold maximum value for resultant force. If the value is 0, it becomes disabled.
Setting range: 0 to 2147483647, Unit: [N]

9 THRESHOLD-XYZLOW
Set the force detection threshold minimum value for resultant force. If the value is 0, it becomes disabled.
Setting range: 0 to 2147483647, Unit: [N]

10 TIME
Specify the detection judgment time. It is judged as detection when the force over threshold continues during the detection judgment time.
Setting range: 0 to 2147483647, Unit: [ms]

<When Method=2 for 1>

2 THRESHOLD-XHIGH
Set the force impulse detection threshold maximum value for X direction. If the value is 0, it becomes disabled.
Setting range: -2147483647 to 2147483647, Unit: [0.01 N.s]

3 THRESHOLD-XLOW
Set the force impulse detection threshold minimum value for X direction. If the value is 0, it becomes disabled.
Setting range: -2147483647 to 2147483647, Unit: [0.01 N.s]
3 Commands for the MotoFit Function
3.7 FDET (Macro Instruction)

4 THRESHOLD-YHIGH
Set the force impulse detection threshold maximum value for Y direction. If the value is 0, it becomes disabled.
Setting range: -2147483647 to 2147483647, Unit: [0.01 N\(\cdot\)s]

5 THRESHOLD-YLOW
Set the force impulse detection threshold minimum value for Y direction. If the value is 0, it becomes disabled.
Setting range: -2147483647 to 2147483647, Unit: [0.01 N\(\cdot\)s]

6 THRESHOLD-ZHIGH
Set the force impulse detection threshold maximum value for Z direction. If the value is 0, it becomes disabled.
Setting range: -2147483647 to 2147483647, Unit: [0.01 N\(\cdot\)s]

7 THRESHOLD-ZLOW
Set the force impulse detection threshold minimum value for Z direction. If the value is 0, it becomes disabled.
Setting range: -2147483647 to 2147483647, Unit: [0.01 N\(\cdot\)s]

8 THRESHOLD-XYZHIGH
Set the force impulse detection threshold maximum value for resultant force. If the value is 0, it becomes disabled.
Setting range: 0 to 2147483647, Unit: [0.01 N\(\cdot\)s]

9 THRESHOLD-XYZLOW
Set the force impulse detection threshold minimum value for resultant force. If the value is 0, it becomes disabled.
Setting range: 0 to 2147483647, Unit: [0.01 N\(\cdot\)s]

10 TIME
This is unused parameter. Even though the value is set, it is not reflected to the command.
Setting range: 0 to 2147483647
3.7 FDET (Macro Instruction)

There are two kinds of FDET command detection method as shown below. One is force detection which judges a detection if the force exceeds the threshold during the judgment time, and the other is impulse detection which judges as detection if the impulse exceeds the threshold.

Table 3-7: External Force Detection Method

<table>
<thead>
<tr>
<th>Detection Method</th>
<th>Parameter</th>
<th>Outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force</td>
<td>Threshold, Judgment time</td>
<td>Detection is judged if the force exceeds the threshold for the duration of the judgment time.</td>
</tr>
<tr>
<td>Impulse</td>
<td>Threshold</td>
<td>Detection is judged if the impulse force exceeds the threshold.</td>
</tr>
</tbody>
</table>
Impulse is to add up the force by time as shown in Fig. 3-3 “Impulse”. The advantage of using impulse is shown in Table 3-8 "Advantage of Impulse" on page 3-16.

If not detecting relatively small force, select force detection.

*Fig. 3-3: Impulse*

![Impulse Diagram](image)

**Table 3-8: Advantage of Impulse**

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Reference diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong> The momentary force change caused by noise or an operation has small affection to the impulse change.</td>
<td><img src="image" alt="Reference Diagram 1" /></td>
</tr>
<tr>
<td><strong>2</strong> Even though the force gap between the normal operation and the unusual operation is relatively small, the gap increases as time goes by.</td>
<td><img src="image" alt="Reference Diagram 2" /></td>
</tr>
</tbody>
</table>
3.8 IMPOFF (Macro Instruction)

IMPOFF is a command that returns to position control from the force control state. After, force control becomes invalid. This is the same command as IMPOFF function by SKILLSND shown section 3.1 “IMPOFF” on page 3-1.

If the robot whose force control becomes OFF is R1, select IMPOFFR1 from [COMMAND LIST], and select IMPOFFR2 if the robot is R2.
4 Registration of Command

Register a command when the cursor is in the address area of the JOB CONTENT display when the robot is in the Teach mode.

1. Select {JOB} in the main menu.
2. Select {JOB CONTENT}.
   - The JOB CONTENT display appears.

Although JOBs (command and others) are normally edited using the MotoFit Function Engineering Support Tool, the inputting method from "PP" is explained in this section. Refer to the Instruction Manual for the DX200 MotoFit Function Engineering Support Tool for the usage of the MotoFit Function Engineering Support Tool.
4.1 IMPOFF

(1) Move the cursor to the line just above the position to which "IMPOFF" is intended to be registered.

(2) Press [COMMAND LIST], and press (OTHER).
   - The COMMAND LIST dialog appears.

(3) Select the {SKILLSND} command.
   - The SKILLSND "COMMAND" appears on the input buffer line.

(4) Input a command as the parameter. (Here, input "IOF").
   - Put the cursor on "SKILLSND" command on the input buffer line, and press [SELECT] to display the DETAIL EDIT display.
   - Put the cursor on "COMMAND" of SKILL COMMAND, and press [SELECT]. Here, input "IOF" in the displayed input dialog box.

(5) Press [ENTER].
   - The DETAIL EDIT display closes and the JOB CONTENT display appears.

(6) Press [ADD], and press [ENTER].
   - The command displayed on the input buffer line is registered.
4.2 TOUCH

(1) Move the cursor to the line just above the position to which "TOUCH" is intended to be registered.

(2) Press [COMMAND LIST], and press {OTHER}.
   - The COMMAND LIST dialog appears.

(3) Select the {SKILLSEND} command.
   - The SKILLSEND "COMMAND" appears on the input buffer line.

(4) Input a command as the parameter. (Here, input "TCH:1:10:5:5:10:3:1" as an example.)
   - Put the cursor on the "SKILLSEND" command on the input buffer line, and press [SELECT] to display the DETAIL EDIT display.
   - Put the cursor on "COMMAND" of SKILL COMMAND, and press [SELECT]. Here, input "TCH:1:10:5:5:10:3:1" in the displayed input dialog box.

(5) Press [ENTER].
   - The DETAIL EDIT display closes and the JOB CONTENT display appears.

(6) Press [ADD], and press [ENTER].
   - The command displayed on the input buffer line is registered.
4.3 FIT

(1) Move the cursor to the line just above the position to which "FIT" is intended to be registered.

(2) Press [COMMAND LIST], and press (OTHER).
   - The COMMAND LIST dialog appears.

(3) Select the {SKILLSND} command.
   - The SKILLSND "COMMAND" appears on the input buffer line.

(4) Input a command as the parameter. (Here, input "FIT:1:10:3:2:2:250:4:3" as an example.)
   - Put the cursor on the "SKILLSND" command on the input buffer line, and press [SELECT] to display the DETAIL EDIT display.
   - Put the cursor on "COMMAND" of SKILL COMMAND, and press [SELECT]. Here, input "FIT:1:10:3:2:2:250:4:3" in the displayed input dialog box.

(5) Press [ENTER].
   - The DETAIL EDIT display closes and the JOB CONTENT display appears.

(6) Press [ADD], and press [ENTER].
   - The command displayed on the input buffer line is registered.
4.4 INSERT

(1) Move the cursor to the line just above the position to which "FIT" is intended to be registered.

(2) Press [COMMAND LIST], and press {OTHER}.
   - The COMMAND LIST dialog appears.

(3) Select the {SKILL SND} command.
   - The SKILL SND "COMMAND" appears on the input buffer line.

(4) Input a command as the parameter. (Here, input "INS:1:20:19:20:1:3:200:0:10" as an example.)
   - Put the cursor on "SKILL SND" command on the input buffer line, and press [SELECT] to display the DETAIL EDIT display.
   - Put the cursor on "COMMAND" of SKILL COMMAND, and press [SELECT]. Here, input "INS:1:20:19:20:1:3:200:0:10" in the displayed input dialog box.

(5) Press [ENTER].
   - The DETAIL EDIT display closes and the JOB CONTENT display appears.

(6) Press [ADD], and press [ENTER].
   - The command displayed on the input buffer line is registered.
4. Registration of Command
4.5 IMPON (Macro Instruction)

1. Move the cursor to the line just above the position to which "IMPON" is intended to be registered.

2. Press [COMMAND LIST], and press {MACRO}.
   - The COMMAND LIST dialog appears.

3. Select {IMPON-R1} command (In case of dual-arm robot's R-arm, select {IMPON-R2} command).
   - The ARGUMENT SETTING display appears.

4. Set the parameter for the IMPON command in the ARGUMENT SETTING display.

5. Press [ENTER].
   - The ARGUMENT SETTING display closes and the JOB CONTENT display appears.

6. Press [ADD], and press [ENTER].
   - The command displayed on the input buffer line is registered
4.6 FREF (Macro Instruction)

1. Move the cursor to the line just above the position to which "FREF" is intended to be registered.

2. Press [COMMAND LIST], and press {MACRO}.
   - The COMMAND LIST dialog appears.

3. Select {FREF-R1} command (In case of dual-arm robot's R-arm, select {FREF-R2} command).
   - The ARGUMENT SETTING display appears.

4. Set the parameter for the FREF command in the ARGUMENT SETTING display.

5. Press [ENTER].
   - The ARGUMENT SETTING display closes and the JOB CONTENT display appears.

6. Press [ADD], and press [ENTER].
   - The command displayed on the input buffer line is registered.
**4.7 FDET (Macro Instruction)**

1. Move the cursor to the line just above the position to which "FDET" is intended to be registered.

2. Press [COMMAND LIST], and press {MACRO}.
   - The COMMAND LIST dialog appears.

3. Select {FDET-R1} command (In case of dual-arm robot's R-arm, select {FDET-R2} command).
   - The ARGUMENT SETTING display appears.

4. Set the parameter for the FDET command in the ARGUMENT SETTING display.

5. Press [ENTER].
   - The ARGUMENT SETTING display closes and the JOB CONTENT display appears.

6. Press [ADD], and press [ENTER].
   - The command displayed on the input buffer line is registered.
4.8 IMPOFF (Macro Instruction)

1. Move the cursor to the line just above the position to which "IMPOFF" is intended to be registered.
2. Press [COMMAND LIST], and press (MACRO).
   – The COMMAND LIST dialog appears.
3. Select {IMPOFF-R1} command (In case of dual-arm robot's R-arm, select {IMPOFF-R2} command).
   – "IMPOFFR1" (or "IMPOFFR2") appears on the input buffer line.
4. Press [ADD], and press [ENTER].
   – The command displayed on the input buffer line is registered.
# 5 Alarm and Status Output Signal

## 5.1 Alarm List

<table>
<thead>
<tr>
<th>Alarm No.</th>
<th>Alarm Name</th>
<th>Meaning</th>
<th>Cause</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>831</td>
<td>Force sensor communication status error</td>
<td>Sub-code: Shows Option board No. × 1000 + Channel × 100 + Factor. Factor: 1: Sending error 2: Sending time-out 3: Receiving error 4: Receiving time-out 5: Protocol error 0: Other error</td>
<td>Software (Operational error)</td>
<td>(1) After confirming the following items, turn OFF the power supply and turn it ON again. &lt;br&gt;• Connection of communication. cable &lt;br&gt;• Type of connected force sensor &lt;br&gt;(2) If the alarm is issued again, save &quot;CMOS.BIN&quot; in the Maintenance mode, and contact Yaskawa service representative, reporting of the situation (operation steps, etc.) when the alarm was issued.</td>
</tr>
<tr>
<td>4887</td>
<td>Force control conditions designation setting error</td>
<td>Sub-code: Shows + Factor. Factor: Sub-code (binary) D0: Tool No. designation error D1: Coordinate designation error D2: Setting error of singular point neighborhood value D3: Inertia setting error D4: Viscosity setting error D5: Rigidity setting error D6: Position limit setting error D7: Speed limit setting error D8: Angular velocity limit setting error D9: Angular velocity alarm setting error D10: Speed loop integration at touch designation error</td>
<td>Software (Setting error)</td>
<td>(1) Reset the alarm and correct the content of the set parameter. &lt;br&gt;(2) If the alarm is issued again, save &quot;CMOS.BIN&quot; in the Maintenance mode, and contact Yaskawa service representative, reporting of the situation (operation steps, etc.) when the alarm was issued.</td>
</tr>
<tr>
<td>4880</td>
<td>Excess force detection error</td>
<td>Sub-code: Shows + Factor. Factor: Sub-code (binary) D0:Fx D1:Fy D2:Fz D3:Mx D4:My D5:Mz</td>
<td>Software (Setting error)</td>
<td>(1) Reset the alarm, and confirm the direction of external forces (sensor coordinate system) by using sub-code, and then move the robot to a position where external forces do not act. &lt;br&gt;(2) If the alarm is issued again, save &quot;CMOS.BIN&quot; in the Maintenance mode, and contact Yaskawa service representative, reporting of the situation (operation steps, etc.) when the alarm was issued.</td>
</tr>
</tbody>
</table>
Table 5-1: Alarm List (Sheet 2 of 5)

<table>
<thead>
<tr>
<th>Alarm No.</th>
<th>Alarm Name</th>
<th>Meaning</th>
<th>Cause</th>
<th>Corrective Action</th>
</tr>
</thead>
</table>
| 4881      | Excess speed correction        | Sub-code: Shows + Axis information. | Software (Setting error)     | (1) Reset the alarm, and decrease the force command value or move the robot to a position where the acting external forces lessen.  
(2) If the alarm is issued again, save "CMOS.BIN" in the Maintenance mode, and contact Yaskawa service representative, reporting of the situation (operation steps, etc.) when the alarm was issued. |
| 4882      | Singular point error           | Sub-code: Shows + Axis information. | Software (Setting error)     | (1) Reset the alarm, change the robot's attitude, and correct the JOB.  
(2) If the alarm is issued again, save "CMOS.BIN" in the Maintenance mode, and contact Yaskawa service representative, reporting of the situation (operation steps, etc.) when the alarm was issued. |
| 4884      | Force control function designation error | Sub-code: Shows + Axis information. | Software (Setting error)     | (1) Reset the alarm, and purchase the Yaskawa’s force control application function.  
(2) If the alarm is issued again even though the function has been purchased, save "CMOS.BIN" in the Maintenance mode, and contact Yaskawa service representative, reporting of the situation (operation steps, etc.) when the alarm was issued. |
| 4898      | Segment over (SV)              | Sub-code: Shows + Axis information. | Software (Setting error)     | (1) Reset the alarm, and decrease the operation speed in the force control mode or confirm whether or not the robot is in a singular point attitude.  
(2) If the alarm is issued again, save "CMOS.BIN" in the Maintenance mode, and contact Yaskawa service representative, reporting of the situation (operation steps, etc.) when the alarm was issued. |
Table 5-1: Alarm List (Sheet 3 of 5)

<table>
<thead>
<tr>
<th>Alarm No.</th>
<th>Alarm Name</th>
<th>Meaning</th>
<th>Cause</th>
<th>Corrective Action</th>
</tr>
</thead>
</table>
| 4899      | Segment over (Safety speed 1) (SV) | Sub-code: Shows + Axis information.                                     | Software (Setting error)   | (1) Reset the alarm, and decrease the operation speed in the force control mode or confirm whether or not the robot is in a singular point attitude.  
(2) If the alarm is issued again, save "CMOS.BIN" in the Maintenance mode, and contact Yaskawa service representative, reporting of the situation (operation steps, etc.) when the alarm was issued. |
| 4900      | Segment over (Safety speed 2) (SV) | Sub-code: Shows + Axis information.                                     | Software (Setting error)   | (1) Reset the alarm, and decrease the operation speed in the force control mode or confirm whether or not the robot is in a singular point attitude.  
(2) If the alarm is issued again, save "CMOS.BIN" in the Maintenance mode, and contact Yaskawa service representative, reporting of the situation (operation steps, etc.) when the alarm was issued. |
| 8008      | ALM FSE-TOOL OPEN FCONCND    | The force condition file could not be read.                            | Software (Setting error)   | (1) Check the followings and then turn ON the power again. 
• Connection status of the communication cable 
• Force sensor type being connected 
(2) If this alarm occurs again, save CMOS.BIN in maintenance mode and tell the situation of the alarm occurrence (such as the operation procedures) to your YASKAWA representative. |
| 8009      | ALM ARG ERR                  | The parameter for force sensor basic command (macro command) was executed in a status out of setting range. | Software (Setting error)   | Confirm that the parameter for the force sensor basic command is set in the setting range.                                                     |
| 8011      | FCON ROBOT ERR               | The force condition file and the control group in the execution JOB are different. | Software (Setting error)   | Set so that the setting for the force condition file and the control group in the execution JOB match.                                         |
| 8012      | IMP ON ERR                   | FREF or FDET was executed in a status where IMPON was not executed.     | Software (Setting error)   | Before FREF or FDET is executed, execute IMPON.                                                                                               |
| 8015      | ALM IF MODE                  | In IF panel, the MotoFit function command was executed in the PP operation mode status. | Software (Setting error)   | When executing the MotoFit function command, set to the PP operation enable mode.                                                             |
| 8017      | ALM UNMATCH COMMAND          | Executing SKILLSND                                                      | Software (Setting error)   | Execute MotoFit or force sensor basic command.                                                                                               |
### 5.1 Alarm List

#### Table 5-1: Alarm List (Sheet 4 of 5)

<table>
<thead>
<tr>
<th>Alarm No.</th>
<th>Alarm Name</th>
<th>Meaning</th>
<th>Cause</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>8102</td>
<td>ALM TOOLNO ERR</td>
<td>On the IF panel, the tool number is set outside the range of 1-16.</td>
<td>Software (Setting error)</td>
<td>Specify the tool number in the range of 1-16 on the IF panel.</td>
</tr>
<tr>
<td>8027</td>
<td>ALM EGT JOB SIZE</td>
<td>The job size sent to PC is outside the allowable range.</td>
<td></td>
<td>The JOB size sent to PC should be less than 2 kByte.</td>
</tr>
<tr>
<td>8100</td>
<td>ALM_MOTOFIT_CMD (FIT command error)</td>
<td>Sub-code: 1</td>
<td>Software (Setting error)</td>
<td>There is a mistake in the description format of the force condition file. Check the description.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sub-code: 11</td>
<td></td>
<td>A certain parameter in the force condition file has exceeded its setting range. Check the description.</td>
</tr>
<tr>
<td>8101</td>
<td>ALM_SKILLSND_CMD (SKILLSND command error)</td>
<td>Sub-code: 1</td>
<td>Software (Setting error)</td>
<td>There is a mistake in the form (.etc.) of the text following a SKILLSND command. Check the description.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sub-code: 2</td>
<td></td>
<td>There is a mistake in the number of the tags set by the text following a SKILLSND command. Check the description and perform the fit job from the beginning again.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sub-code: 11</td>
<td></td>
<td>The tags set by the text following a SKILLSND command has exceeded the setting range. Check the description.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sub-code: 12</td>
<td></td>
<td>There is a combination error in the command tags set by the text following a SKILLSND command. Check the description and perform the fit job from the beginning again.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sub-code: 20</td>
<td></td>
<td>The SKILLSND command was executed while the engineering tool operation is valid. Check the setting of IF Panel.</td>
</tr>
<tr>
<td>8102</td>
<td>ALM_MOTOFIT_CMD_STEP (FIT command execution step error)</td>
<td>Sub-code: 1</td>
<td>Software (Setting error)</td>
<td>A FIT or INSERT command was executed though any TOUCH command had not been executed. Check the operation steps of commands and perform the fit job from the beginning again.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sub-code: 11</td>
<td></td>
<td>There is a disagreement in the settings of the force conditions (robot ID, Fit direction, coordinate system, etc.) between a TOUCH command and a FIT or INSERT command. Check the descriptions of the commands or the force condition files and perform the fit job from the beginning again.</td>
</tr>
</tbody>
</table>
### Table 5-1: Alarm List (Sheet 5 of 5)

<table>
<thead>
<tr>
<th>Alarm No.</th>
<th>Alarm Name</th>
<th>Meaning</th>
<th>Cause</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>8103</td>
<td>ALM_INST_EXEC (Command execution error)</td>
<td>Sub-code: Target robot (1 or 2)</td>
<td>Software (Setting error)</td>
<td>A Fit command was executed from the job that has two or more RB control groups. Check the settings of the control group for the job that executes a Fit command.</td>
</tr>
</tbody>
</table>
5.2 System Output

Table 5-2 "System Output of MotoFit Function" shows the special output of this function.

Table 5-2: System Output of MotoFit Function

<table>
<thead>
<tr>
<th>Status</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impedance control proceeding</td>
<td>51100</td>
</tr>
<tr>
<td>Inner force sensor offset value calculation complete</td>
<td>51110</td>
</tr>
</tbody>
</table>

5.3 General Output

Table 5-3 "General Output of MotoFit Function" shows the general output of this function.

Table 5-3: General Output of MotoFit Function

<table>
<thead>
<tr>
<th>Status</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIT command (TOUCH) successful</td>
<td>11270</td>
</tr>
<tr>
<td>FIT command (FIT) successful</td>
<td>11271</td>
</tr>
<tr>
<td>FIT command (INSERT) successful</td>
<td>11272</td>
</tr>
<tr>
<td>FIT command (TOUCH) job end</td>
<td>11273</td>
</tr>
<tr>
<td>FIT command (FIT) job end</td>
<td>11274</td>
</tr>
<tr>
<td>FIT command (INSERT) job end</td>
<td>11275</td>
</tr>
</tbody>
</table>
6 Remarks

6.1 Operation When the MotoFit Function is Working

When the MotoFit function is working, the robot may not operate as instructed by a teach position, teach trace, etc. since the position compensation function works by the inner force sense feedback control.

6.2 Usage of "TOUCH", "FIT", and "INSERT"

Use the TOUCH, FIT, and INSERT commands in the operation step of TOUCH→FIT→INSERT or TOUCH→INSERT. Independent use of "FIT" or "INSERT", a usage in unspecified steps, and usage with "WAIT" in-between are prohibited. Besides, Alarm 8102 "Fit command execution step error" is issued if a FIT or INSERT command is executed when a TOUCH command has not been executed yet.

6.3 Operation while a TIMER or WAIT Command is Executed

Any TIMER or WAIT command can be executed even when the force control is effective by the execution of a TOUCH, FIT, or INSERT command. In this case, the robot does not necessarily stop since it stops the execution of a job while holding the preceding force command value. Be sure to confirm the safety in operation through a test operation before performing the playback operation.

6.4 Using the MotoFit Function in a Test Operation

The MotoFit function can be used in the test operation mode as well as in the playback operation mode. However, the force control becomes invalid if operation is interrupted by quitting pushing down of a key or turning OFF the servo. In such a case, move the robot to its job start point by moving the cursor, and restart operation.

6.5 Using the MotoFit Function during the Machine-Lock Operation

When a TOUCH, FIT, or INSERT command is used with the Machine-Lock operation mode ON, the force control is invalidated. In this case, the manipulator does not operate and the job completion signal is output as soon as the command is executed. Note that the present value is not renewed even if an "IMPOFF" command is executed during the Machine-Lock operation.
6.6 Interruption of Operation While the MotoFit Function Executes

When the robot's operation is interrupted by any of the following measures while the MotoFit function executes, the force control is invalidated and normal position control is restored. To restart the robot's operation, move the robot to the previous position at which the force control started, move the cursor, and make confirmation before restarting.

- PAUSE command
- Hold operation
- Emergency stop operation
- Servo OFF operation

* This does not correspond to the individual hold operation per each subtask by system input signals.

6.7 Step Execution

The MotoFit function does not work in the step execution mode, because once executed, the function cannot be interrupted. Therefore, any MotoFit command is skipped in the step execution mode.

6.8 Restrictions of Usage Environment

This function can be used only in the assembly line. Using in the welding line is prohibited.

6.9 Holding of Workpiece by Hand

Design the hand in the structure that can hold a workpiece firmly. If a workpiece slips from the hand changing its position relative to the hand, the workpiece may not fit to its mating part as instructed.

Slip may occur between a workpiece and the hand due to the reaction force of search or other operation.

6.10 JOB Operation with Multiple Control Groups

This function does not operate in the JOB with the multiple control groups. When the force control need to be applied to the multiple control groups, divide the JOB into every control group.
6.11 Payload of the Robot

Include the mass of force sensor to the payload. Refer to Table 6-1 "Mass and Maximum Static Load of the Force Sensor" for the mass of force sensor.

6.12 Maximum load of the force sensor

Do not exceed the maximum static load of the force sensor.

For the axis definition of force sensor, refer to following figure. For the maximum static load of the force sensor, refer to Table 6-1.

Also refer to the "allowable load for wrist axis" in the specifications of the manipulator.

![Diagram of force sensor](attachment:image.png)

Table 6-1: Mass and Maximum Static Load of the Force Sensor

<table>
<thead>
<tr>
<th></th>
<th>WEF-6A200-4-RG24</th>
<th>WEF-6A1000-30-RG24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>360 g</td>
<td>500 g</td>
</tr>
<tr>
<td>Maximum Static Load (Translation) (Fx, Fy, Fz)</td>
<td>1000 N</td>
<td>5000 N</td>
</tr>
<tr>
<td>Maximum Static Load (Moment) (Rx, Ry, Rz)</td>
<td>6.0 N·m</td>
<td>50 N·m</td>
</tr>
</tbody>
</table>

6.13 Restriction of Fit Direction

The sensor rated 200N (WEF-6A200-4-RG24) can be used for fitting downward only.
6.14 Sensor Cable Outfitting

When outfitting the sensor cable, check with actual motion pattern before adjusting the cable length.

For outfitting, make sure to protect the cable with using a spiral tube, etc.

For the installation hole of the manipulator, refer to the instructions of the manipulator.

CAUTION

Ensure a sufficient length of the cable from the sensor connector to the cable clamp, and note that the bend radius of the sensor connector should not be 41 mm or less.
DX200 OPTIONS
INSTRUCTIONS
for MotoFit

Specifications are subject to change without notice for ongoing product modifications and improvements.