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

MOTOMAN INSTRUCTIONS

DX200 INSTRUCTIONS
DX200 OPERATOR'S MANUAL (for each purpose)
DX200 MAINTENANCE MANUAL

FS100 INSTRUCTIONS
FS100 OPERATOR'S MANUAL
FS100 MAINTENANCE MANUAL

The DX200 operator’s manual above corresponds to specific usage. Be sure to use the appropriate manual. The FS100 OPERATOR’S MANUAL above is applicable to both FS100 and FS100L controllers.

Please have the following information available when contacting Yaskawa Customer Support:

- System
- Primary Application
- Software Version (Located on Programming Pendant by selecting: [Main Menu] - [System Info] - [Version])
  - Robot Serial Number (Located on robot data plate)
  - Robot Sales Order Number (Located on controller data plate)

Part Number: 165456-1CD
Revision: 8
MANDATORY

- This manual explains MotoFit of the DX200/FS100 system. Read this manual carefully and be sure to understand its contents before handling the DX200/FS100.
- General items related to safety are listed in the Chapter 1: Safety of the DX200/FS100 Instructions. To ensure correct and safe operation, carefully read the DX200/FS100 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.
NOTES FOR SAFE OPERATION

Read this manual carefully before installation, operation, maintenance, or inspection of the DX200/FS100.

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.

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

3/117
<DX200>

WARNING

• Before operating the manipulator, check that servo power is turned OFF pressing the emergency stop buttons on the front door of the DX200 and the programming pendant. When the servo power is turned OFF, the SERVO ON LED on the programming 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.

Fig. : 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.

Fig. : 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.
  – Keep in mind the emergency response measures against the manipulator’s unexpected motion toward you.
  – 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 P-point maximum envelope of the manipulator during operation. Always press an emergency stop button immediately if there is a problem.

The emergency stop buttons are located on the right of front door of the DX200 and the programming pendant.
### WARNING

- Before operating the manipulator, check that servo power is turned OFF when the emergency stop button on the programming pendant is pressed. When the servo power is turned OFF, the SERVO ON LED on the programming 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.

*Fig. : Emergency Stop Button*

- In the case of not using the programming pendant, be sure to supply the emergency stop button on the equipment. Then before operating the manipulator, check to be sure that the servo power is turned OFF by pressing the emergency stop button. Connect the external emergency stop button to the 5-6 pin and 16-17 pin of the robot system signal connector (CN2).

- Upon shipment of the FS100, this signal is connected by a jumper cable in the dummy connector. To use the signal, make sure to supply a new connector, and then input it.

If the signal is input with the jumper cable connected, it does not function, which may result in personal injury or equipment damage.

- 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.

*Fig. : 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.
  - Keep in mind the emergency response measures against the manipulator’s unexpected motion toward you.
  - Ensure that you have a safe place to retreat in case of emergency.

Improper or unintended manipulator operation may result in injury.
WARNING

• Confirm that no person is present in the manipulator’s operating range and that you are in a safe location before:
  – Turning ON the DX200/FS100 power.
  – Moving the manipulator with the programming pendant.
  – Running the system in the check mode.
  – Performing automatic operations.

Injury may result if anyone enters the manipulator’s operating range during operation. Always press the emergency stop button immediately if there is a problem. The emergency stop button is located on the right of the programming pendant.

CAUTION

• Perform the following inspection procedures prior to conducting manipulator teaching. If problems are found, repair them immediately, and be sure that all other necessary processing has been performed.
  – Check for problems in manipulator movement.
  – Check for damage to insulation and sheathing of external wires.

• Always return the programming pendant to the hook on the DX200/FS100 cabinet after use.

The programming pendant can be damaged if it is left in the manipulator’s work area, on the floor, or near fixtures.

• Read and understand the Explanation of the Warning Labels in the DX200/FS100 Instructions before operating the manipulator.

• When operate a robot, make sure that a sensor cable is not twined around the peripheral devices. Especially in a working posture that the robot contacts to a workpiece, make sure not to pinch the cable between the robot and the workpiece.
Definition of Terms Used Often in This Manual (DX200)

The MOTOMAN is the YASKAWA industrial robot product.

The MOTOMAN usually consists of the manipulator, the controller, the programming pendant, and the manipulator 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 DX200 controller</td>
<td>Manipulator cable</td>
</tr>
</tbody>
</table>

Definition of Terms Used Often in This Manual (FS100)

The MOTOMAN is the YASKAWA industrial robot product.

The MOTOMAN usually consists of the manipulator, the FS100 controller, manipulator cables, the FS100 programming pendant (optional), and the FS100 programming pendant dummy connector (optional).

In this manual, the equipment is designated as follows:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Manual Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>FS100 controller</td>
<td>FS100</td>
</tr>
<tr>
<td>FS100 programming pendant</td>
<td>Programming pendant</td>
</tr>
<tr>
<td>Cable between the manipulator and the controller</td>
<td>Manipulator Cable</td>
</tr>
<tr>
<td>FS100 programming pendant dummy connector</td>
<td>Programming pendant dummy connector</td>
</tr>
</tbody>
</table>
Descriptions of the programming pendant keys, buttons, displays and keyboard of the PC 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 The keys which have characters printed on them are denoted with [ ].</td>
</tr>
<tr>
<td></td>
<td>e.g. [ENTER]</td>
</tr>
<tr>
<td>Symbol Keys</td>
<td>The keys which have a symbol printed on them are not denoted with [ ] but depicted with a small picture.</td>
</tr>
<tr>
<td></td>
<td>e.g. PAGE key</td>
</tr>
<tr>
<td></td>
<td>The cursor key is an exception, and a picture is not shown.</td>
</tr>
<tr>
<td>Axis Keys</td>
<td>&quot;Axis keys&quot; and &quot;Numeric keys&quot; are generic names for the keys for axis operation and number input.</td>
</tr>
<tr>
<td>Numeric Keys</td>
<td></td>
</tr>
<tr>
<td>Keys Pressed</td>
<td>When two keys are to be pressed simultaneously, the keys are shown with a &quot;+&quot; sign between them.</td>
</tr>
<tr>
<td>Simultaneously</td>
<td>e.g. SHIFT key + COORD key</td>
</tr>
<tr>
<td>Mode Key</td>
<td>Three kinds of modes that can be selected by the mode key are denoted as follows:</td>
</tr>
<tr>
<td></td>
<td>REMOTE, PLAY, or TEACH</td>
</tr>
<tr>
<td>Button</td>
<td>Three buttons on the upper side of the programming pendant are denoted as follows:</td>
</tr>
<tr>
<td></td>
<td>HOLD button</td>
</tr>
<tr>
<td></td>
<td>START button</td>
</tr>
<tr>
<td></td>
<td>EMERGENCY STOP button</td>
</tr>
<tr>
<td>Displays</td>
<td>The menu displayed in the programming pendant is denoted with { }.</td>
</tr>
<tr>
<td></td>
<td>e.g. {JOB}</td>
</tr>
<tr>
<td>PC Keyboard</td>
<td>The name of the key is denoted.</td>
</tr>
<tr>
<td></td>
<td>e.g. Ctrl key on the keyboard</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 [SELECT] is pressed.

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## Contents

1 MotoFit Function ............................................................................................................................. 1-1  
   1.1 Overview of MotoFit Function ............................................................................................ 1-1  
   1.2 System Configuration of MotoFit Function........................................................................ 1-2  
      1.2.1 System Configuration ........................................................................................... 1-2  
      1.2.2 Signals and Variables Used in MotoFit Function.................................................. 1-4  
   1.3 Usage Example of MotoFit Function.................................................................................. 1-8  
      1.3.1 Fitting Operation for Cylindrical Workpiece .......................................................... 1-8  
      1.3.2 Applying Tape ...................................................................................................... 1-8  
      1.3.3 Polishing operation............................................................................................... 1-9  

2 Set Up of MotoFit Function ............................................................................................................. 2-1  
   2.1 Mounting the 6-axis Force Sensor..................................................................................... 2-1  
   2.2 Connection and Outfitting of Sensor Cable ....................................................................... 2-1  
      2.2.1 Sensor Cable Connection..................................................................................... 2-1  
      2.2.2 Notes for Sensor Cable Outfitting......................................................................... 2-2  
   2.3 Operation Check.......................................................................................................... 2-3  
      2.3.1 Startup Check....................................................................................................... 2-3  
      2.3.2 Mounting Direction of Force Sensor... .................................................................. 2-4  

3 Commands for MotoFit Function.............................................................................................. 3-1  
   3.1 Force Condition File........................................................................................................... 3-2  
   3.2 IMPOFF ............................................................................................................................. 3-3  
      3.2.1 Details of IMPOFF................................................................................................ 3-3  
      3.2.2 Registration of IMPOFF........................................................................................ 3-3  
   3.3 TOUCH.................................................................................................................... 3-5  
      3.3.1 Details of TOUCH................................................................................................. 3-5  
      3.3.2 Registration of TOUCH......................................................................................... 3-6  
   3.4 FIT .................................................................................................................................... 3-8  
      3.4.1 Details of FIT ........................................................................................................ 3-8  
      3.4.2 Registration of FIT .............................................................................................. 3-10  
   3.5 INSERT............................................................................................................................ 3-11  
      3.5.1 Details of INSERT ............................................................................................... 3-11  
      3.5.2 Registration of INSERT...................................................................................... 3-14  
   3.6 IMPON (Macro Instruction).............................................................................................. 3-15  
      3.6.1 Details of IMPON................................................................................................. 3-15
3.6.2 Registration of IMPON ........................................................................................3-17

3.7 FREF (Macro Instruction) ..........................................................................................3-18
  3.7.1 Details of FREF (Macro Instruction) .................................................................3-18
  3.7.2 Registration of FREF (Macro Instruction) .........................................................3-20

3.8 FDET (Macro Instruction) ..........................................................................................3-21
  3.8.1 Details of FDET (Macro Instruction) .................................................................3-21
  3.8.2 Registration of FDET (Macro Instruction) .........................................................3-27

3.9 IMPOFF (Macro Instruction) ......................................................................................3-28
  3.9.1 Details of IMPOFF (Macro Instruction) ..............................................................3-28
  3.9.2 Registration of IMPOFF (Macro Instruction) ......................................................3-28

3.10 RESCALE (FS100 only) ............................................................................................3-29
  3.10.1 Details of RESCALE .......................................................................................3-29
  3.10.2 Registration of RESCALE ...............................................................................3-30

4 Example for Creating MotoFit JOB ..............................................................................4-1
  4.1 Fitting Operation for Cylindrical Workpiece ..........................................................4-1
    4.1.1 Procedure to Create the fitting JOB ...............................................................4-2
    4.1.2 Example of Fitting JOB ..................................................................................4-4
    4.1.3 Operation Example of The Fitting JOB ................................................................4-6

4.2 Applying Tape ..............................................................................................................4-9
  4.2.1 Procedure to Create JOB for Applying Tape ....................................................4-9
  4.2.2 Example of JOB for Applying Tape ..................................................................4-12
  4.2.3 Operation Example of JOB for Applying Tape ................................................4-13

4.3 Polishing Operation ....................................................................................................4-14
  4.3.1 Procedure to Create The Polishing JOB .........................................................4-14
  4.3.2 Example of Polishing JOB ................................................................................4-18
  4.3.3 Operation Example of Polishing JOB ...............................................................4-18

5 Status Output Signal ....................................................................................................5-1
  5.1 Force Control Status Signal .....................................................................................5-1
    5.1.1 Special Output ..................................................................................................5-1
    5.1.2 General Output ................................................................................................5-1

5.2 Registers Output Function (FS100) ..........................................................................5-2
    5.2.1 Setting of Registers Output Function ..............................................................5-2
    5.2.2 Registers as Destination of Allocation and Data Type ......................................5-4

5.3 Registers Output Function (DX200) ..........................................................................5-6
7.7 Operation while a TIMER or WAIT Command is Executed ......................................................... 7-3
7.8 Using the MotoFit Function in a Test Operation ........................................................................ 7-3
7.9 Using the MotoFit Function during the Machine-Lock Operation ............................................. 7-3
7.10 Interruption of Operation While the MotoFit Function Executes ........................................... 7-3
7.11 Step Execution ....................................................................................................................... 7-3
7.12 Restrictions of Usage Environment ...................................................................................... 7-4
7.13 Holding of Workpiece by Hand ............................................................................................ 7-4
7.14 JOB Operation with Multiple Control Groups ........................................................................ 7-4
7.15 Payload of the Robot ............................................................................................................ 7-4
7.16 Force Sensor ......................................................................................................................... 7-4

8 Supplemental Information ........................................................................................................... 8-1

8.1 Specifications .......................................................................................................................... 8-1
  8.1.1 Specifications of MotoFit ................................................................................................. 8-1
  8.1.2 Specifications of Force Sensor ........................................................................................ 8-1
8.2 Extended applications by using MotoPlus ............................................................................... 8-1
1 MotoFit Function

1.1 Overview of MotoFit Function

With the MotoFit function, the 6-axis force sensor detects external forces applied on the tool installed at the manipulator's tip to correct the manipulator's position. Thus, a precision fit or polishing operation can be performed by the manipulator.

The 6-axis force sensor which detects 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. On the other hand, with the MotoFit function, the manipulator's position is corrected by the force control to match the force applied on the tool installed at the manipulator's tip with the force command value, so that a precision fit can be performed.

The MotoFit function incorporates the following four special commands suitable for the positioning of precision parts for a clearance from approx. 10 μm to 100 μm.

- SKILLSND "TCH: • • •": TOUCH (TOUCH)
- SKILLSND "FIT: • • •": Search (FIT)
- SKILLSND "INS: • • •": Insertion (INSERT)
- SKILLSND "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 the MotoFit Function Engineering Support Tool [Manual No. HW1481731].)

Besides the above command the four force sense basic commands. (Refer to chapter 3 “Commands for MotoFit Function”)

- IMPON (Macro Instruction)
- FREF (Macro Instruction)
- FDET (Macro Instruction)
- IMPOFF (Macro Instruction)
1.2 System Configuration of MotoFit Function

1.2.1 System Configuration

The MotoFit function consists of the robot, the controller, the 6-axis force sensor, the Interface panel on the programming pendant and PC for teaching which is prepared by user.

*Fig. 1-1: System Configuration of MotoFit Function*

Table 1-1: Components of FS100

<table>
<thead>
<tr>
<th>Device</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robot (Manipulator)</td>
<td>-</td>
</tr>
<tr>
<td>Robot controller (FS100)</td>
<td>• Connected to the 24V power for sensor</td>
</tr>
<tr>
<td></td>
<td>• The setting of MotoFit function is completed</td>
</tr>
<tr>
<td>Power supply cable</td>
<td>-</td>
</tr>
<tr>
<td>Programming pendant</td>
<td>Interface panel for MotoFit</td>
</tr>
<tr>
<td></td>
<td>The setting is completed</td>
</tr>
<tr>
<td>6-axis force sensor</td>
<td>Rated 200N or 1000N</td>
</tr>
<tr>
<td>Sensor cable</td>
<td>Connected to the FS100</td>
</tr>
<tr>
<td>PC for teaching*</td>
<td>OS: Windows7</td>
</tr>
<tr>
<td>LAN cable for PC connection*</td>
<td>-</td>
</tr>
<tr>
<td>Tool for the manipulator’s tip*</td>
<td>-</td>
</tr>
</tbody>
</table>

*PC, LAN cable and Tool are prepared by user.*
1 MotoFit Function
1.2 System Configuration of MotoFit Function

Table 1-2: Components of DX200

<table>
<thead>
<tr>
<th>Device</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robot (Manipulator)</td>
<td>-</td>
</tr>
</tbody>
</table>
| Robot controller (DX200)    | • Built-in the 24V power for sensor  
                              | • The setting of MotoFit function is completed                      |
| Power supply cable          | -                                                                    |
| Programming pendant         | Interface panel for MotoFit                                           |
|                             | The setting is completed                                              |
| 6-axis force sensor         | Rated 200N or 1000N                                                   |
| Sensor cable                |                                                                 |
|                             | Manipulator side                                                      |
|                             | DX200 side                                                            |
| PC for teaching*            | OS: Windows7                                                          |
| LAN cable for PC connection*| -                                                                    |
| Tool for the manipulator’s tip* | -                                      |

*PC, LAN cable and Tool are prepared by user.
1.2.2 Signals and Variables Used in MotoFit Function

The following signals and variables are used in this function. The signals and variables on this chapter must not be used in the JOB which is created by user.

- **System output signal**

The system output signals used in this function are shown in table 1-3 "System Output of MotoFit Function".

<table>
<thead>
<tr>
<th>Destination Status</th>
<th>Logical No.</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>873</td>
<td>51100</td>
<td>Force control proceeding (R1)</td>
</tr>
<tr>
<td>874</td>
<td>51101</td>
<td>Force control proceeding (R2)</td>
</tr>
<tr>
<td>881</td>
<td>51110</td>
<td>Start force measurement (R1)</td>
</tr>
<tr>
<td>882</td>
<td>51111</td>
<td>Start force measurement (R2)</td>
</tr>
</tbody>
</table>

- **General output signal**

The general output signals used in this function are shown in table 1-4 "General Output of MotoFit Function".

<table>
<thead>
<tr>
<th>Destination Status</th>
<th>Logical No.</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>969</td>
<td>11220</td>
<td>Register output function start</td>
</tr>
<tr>
<td>977</td>
<td>11230</td>
<td>Zero reset (Interface panel)</td>
</tr>
<tr>
<td>978</td>
<td>11231</td>
<td>Coordinate system selector switch (Interface panel)</td>
</tr>
<tr>
<td>979</td>
<td>11232</td>
<td>MotoFit reserved</td>
</tr>
<tr>
<td>980</td>
<td>11233</td>
<td>MotoFit reserved</td>
</tr>
<tr>
<td>981</td>
<td>11234</td>
<td>MotoFit reserved</td>
</tr>
<tr>
<td>982</td>
<td>11235</td>
<td>MotoFit reserved</td>
</tr>
<tr>
<td>983</td>
<td>11236</td>
<td>MotoFit reserved</td>
</tr>
<tr>
<td>984</td>
<td>11237</td>
<td>MotoFit reserved</td>
</tr>
<tr>
<td>985</td>
<td>11240</td>
<td>MotoFit reserved</td>
</tr>
<tr>
<td>986</td>
<td>11241</td>
<td>Coordinate system switching display (Interface panel)</td>
</tr>
<tr>
<td>987</td>
<td>11242</td>
<td>MotoFit reserved</td>
</tr>
<tr>
<td>988</td>
<td>11243</td>
<td>MotoFit reserved</td>
</tr>
<tr>
<td>989</td>
<td>11244</td>
<td>IMPON completed (R1)</td>
</tr>
<tr>
<td>990</td>
<td>11245</td>
<td>IMPON completed (R2)</td>
</tr>
<tr>
<td>991</td>
<td>11246</td>
<td>FDET detection (R1)</td>
</tr>
<tr>
<td>992</td>
<td>11247</td>
<td>FDET detection (R2)</td>
</tr>
<tr>
<td>993</td>
<td>11250</td>
<td>Start (Interface panel)</td>
</tr>
<tr>
<td>994</td>
<td>11251</td>
<td>Stop (Interface panel)</td>
</tr>
</tbody>
</table>
Table 1-4: General Output of MotoFit Function

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>995</td>
<td>11252</td>
<td>Mode selector switch (Interface panel)</td>
</tr>
<tr>
<td>996</td>
<td>11253</td>
<td>MotoFit reserved</td>
</tr>
<tr>
<td>997</td>
<td>11254</td>
<td>MotoFit reserved</td>
</tr>
<tr>
<td>998</td>
<td>11255</td>
<td>MotoFit reserved</td>
</tr>
<tr>
<td>999</td>
<td>11256</td>
<td>MotoFit reserved</td>
</tr>
<tr>
<td>1000</td>
<td>11257</td>
<td>MotoFit reserved</td>
</tr>
<tr>
<td>1001</td>
<td>11260</td>
<td>Executing the operation (Interface panel)</td>
</tr>
<tr>
<td>1002</td>
<td>11261</td>
<td>MotoFit reserved</td>
</tr>
<tr>
<td>1003</td>
<td>11262</td>
<td>Mode switching display (Interface panel)</td>
</tr>
<tr>
<td>1004</td>
<td>11263</td>
<td>Setting of TOUCH completed (Interface panel)</td>
</tr>
<tr>
<td>1005</td>
<td>11264</td>
<td>Setting of FIT completed (Interface panel)</td>
</tr>
<tr>
<td>1006</td>
<td>11265</td>
<td>Setting of INSERT completed (Interface panel)</td>
</tr>
<tr>
<td>1007</td>
<td>11266</td>
<td>Setting of arrangement step No.1 completed (Interface panel)</td>
</tr>
<tr>
<td>1008</td>
<td>11267</td>
<td>Setting of arrangement step No.2 completed (Interface panel)</td>
</tr>
<tr>
<td>1009</td>
<td>11270</td>
<td>FIT command (TOUCH) successful (R1)</td>
</tr>
<tr>
<td>1010</td>
<td>11271</td>
<td>FIT command (FIT) successful (R1)</td>
</tr>
<tr>
<td>1011</td>
<td>11272</td>
<td>FIT command (INSERT) successful (R1)</td>
</tr>
<tr>
<td>1012</td>
<td>11273</td>
<td>FIT command (TOUCH) job end (R1)</td>
</tr>
<tr>
<td>1013</td>
<td>11274</td>
<td>FIT command (FIT) job end (R1)</td>
</tr>
<tr>
<td>1014</td>
<td>11275</td>
<td>FIT command (INSERT) job end (R1)</td>
</tr>
<tr>
<td>1015</td>
<td>11276</td>
<td>MotoFit reserved</td>
</tr>
<tr>
<td>1016</td>
<td>11277</td>
<td>MotoFit reserved</td>
</tr>
<tr>
<td>1017</td>
<td>11280</td>
<td>FIT command (TOUCH) successful (R2)</td>
</tr>
<tr>
<td>1018</td>
<td>11281</td>
<td>FIT command (FIT) successful (R2)</td>
</tr>
<tr>
<td>1019</td>
<td>11282</td>
<td>FIT command (INSERT) successful (R2)</td>
</tr>
<tr>
<td>1020</td>
<td>11283</td>
<td>FIT command (TOUCH) job end (R2)</td>
</tr>
<tr>
<td>1021</td>
<td>11284</td>
<td>FIT command (FIT) job end (R2)</td>
</tr>
<tr>
<td>1022</td>
<td>11285</td>
<td>FIT command (INSERT) job end (R2)</td>
</tr>
<tr>
<td>1023</td>
<td>11286</td>
<td>MotoFit reserved</td>
</tr>
<tr>
<td>1024</td>
<td>11287</td>
<td>MotoFit reserved</td>
</tr>
</tbody>
</table>
1 MotoFit Function
1.2 System Configuration of MotoFit Function

- General input signal

The general input signals used in this function are shown in table 1-5 “General Input of MotoFit Function”.

Table 1-5: General Input of MotoFit Function

<table>
<thead>
<tr>
<th>IN#</th>
<th>Logical No.</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>991</td>
<td>01246</td>
<td>FDET detection (R1)</td>
</tr>
<tr>
<td>992</td>
<td>01247</td>
<td>FDET detection (R2)</td>
</tr>
<tr>
<td>1017</td>
<td>01280</td>
<td>Register output function start</td>
</tr>
</tbody>
</table>
## Variable

The variables in table 1-6 “Used Variables of MotoFit Function” used for the force sensor basic command.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>B96</td>
<td>R1 Tool No.</td>
</tr>
<tr>
<td>B97</td>
<td>R2 Tool No.</td>
</tr>
<tr>
<td>D78</td>
<td>R1 General output No. for external force detection (R1)</td>
</tr>
<tr>
<td>D79</td>
<td>R2 General output No. for external force detection (R2)</td>
</tr>
<tr>
<td>D80</td>
<td>Arg1 (R1) of force sensor command</td>
</tr>
<tr>
<td>D81</td>
<td>Arg2 (R1) of force sensor command</td>
</tr>
<tr>
<td>D82</td>
<td>Arg3 (R1) of force sensor command</td>
</tr>
<tr>
<td>D83</td>
<td>Arg4 (R1) of force sensor command</td>
</tr>
<tr>
<td>D84</td>
<td>Arg5 (R1) of force sensor command</td>
</tr>
<tr>
<td>D85</td>
<td>Arg6 (R1) of force sensor command</td>
</tr>
<tr>
<td>D86</td>
<td>Arg7 (R1) of force sensor command</td>
</tr>
<tr>
<td>D87</td>
<td>Arg8 (R1) of force sensor command</td>
</tr>
<tr>
<td>D88</td>
<td>Arg9 (R1) of force sensor command</td>
</tr>
<tr>
<td>D89</td>
<td>Arg10 (R1) of force sensor command</td>
</tr>
<tr>
<td>D90</td>
<td>Arg1 (R2) of force sensor command</td>
</tr>
<tr>
<td>D91</td>
<td>Arg2 (R2) of force sensor command</td>
</tr>
<tr>
<td>D92</td>
<td>Arg3 (R2) of force sensor command</td>
</tr>
<tr>
<td>D93</td>
<td>Arg4 (R2) of force sensor command</td>
</tr>
<tr>
<td>D94</td>
<td>Arg5 (R2) of force sensor command</td>
</tr>
<tr>
<td>D95</td>
<td>Arg6 (R2) of force sensor command</td>
</tr>
<tr>
<td>D96</td>
<td>Arg7 (R2) of force sensor command</td>
</tr>
<tr>
<td>D97</td>
<td>Arg8 (R2) of force sensor command</td>
</tr>
<tr>
<td>D98</td>
<td>Arg9 (R2) of force sensor command</td>
</tr>
<tr>
<td>D99</td>
<td>Arg10 (R2) of force sensor command</td>
</tr>
<tr>
<td>S97</td>
<td>MotoFit ALARM information</td>
</tr>
<tr>
<td>S98</td>
<td>MotoFit MotoPlus version information1</td>
</tr>
<tr>
<td>S99</td>
<td>MotoFit MotoPlus version information2</td>
</tr>
</tbody>
</table>
1.3 Usage Example of MotoFit Function

The following explanation shows typical examples of MotoFit function. For each job example, refer to chapter 4 “Example for Creating MotoFit JOB”.

1.3.1 Fitting Operation for Cylindrical Workpiece

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.

By using the MotoFit function in which the hole search operation command and the insert operation command are available, the fitting operation for the clearance mentioned above can be easily performed.

*Fig. 1-2: Fitting Operation for Workpiece*

![Diagram of Fitting Operation for Workpiece]

1.3.2 Applying Tape

With the MotoFit function, the following commands can be used. The command to press with a constant force and the command to stop the operation when detecting the force which exceeds the specified force. For the applying tape operation as shown in the following figure, the JOB can be created in which the operation is changed when the error is detected due to an applied force which is different from the normal state.

*Fig. 1-3: Applying Tape*

![Diagram of Applying Tape]
1.3.3 Polishing operation

Using the position control to polish a curved surface with a constant force may cause the variation in the polishing quality. By using the MotoFit function, the operation with a constant force along the direction of the tool coordinate is possible for both flat and curved surface.

*Fig. 1-4: Pressing*
2 Set Up of MotoFit Function

2.1 Mounting the 6-axis Force Sensor

The force sensor must be mounted in the accordance with the dimension diagram in Dimension Diagram folder in the distributed CD-ROM.

The mounting direction of the force sensor is different depending on a model of the manipulator. Before the operation check, make sure the sensor is mounted according to the assembly drawing. If the mounting direction is different, the actual operation may be different from the taught operation.

When mounting the force sensor, the spacers other than YASKAWA must not be used. If the other spacers are used, contact YASKAWA representative.

2.2 Connection and Outfitting of Sensor Cable

2.2.1 Sensor Cable Connection

1. Turn OFF the DX200/FS100.
2. For DX200, the sensor cable (DX200 side) is connected to the back side of DX200 and the sensor cable (the manipulator side) is also connected.

*Fig. 2-1: Back Side of DX200*

3. Mount the force sensor on the connector of the sensor cable.
2.2 Connection and Outfitting of Sensor Cable

4. When two force sensors are used for the single-arm manipulators which are controlled for coordinated operation, the force sensor for R2 is also mounted in the same procedures.

*Fig. 2-2: Sensor Connection*

2.2.2 Notes for 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. The bend radius when fixed must be $R=41\text{mm}$ or longer. Fixing the cable clamp with the screw of manipulator's cover may cause failures. Since the torque management of the screw is necessary, be sure to contact YASKAWA representative.
2.3 Operation Check

2.3.1 Startup Check

1. For the FS100, make sure the breaker of the force sensor power box on the side of FS100 is ON. If not, turn it ON.

*Fig. 2-3: Breaker*

2. Turn ON the DX200/FS100 and make sure any Alarm does not occur.

When turning on the robot controller with the sensor cable disconnected from the force sensor, an alarm 0831 “force sensor communication state error” occurs.

**NOTE**

To force the robot to operate with the force sensor not connected, disable the force sensor according to chapter 6.2.1 “Disabling the Force Sensor”.

To re-enable the force sensor, activate the force sensor and set the parameters according to chapter 6.2.2 “Enabling the Force Sensor”.
2.3.2 Mounting Direction of Force Sensor

The mounting direction of the sensor is checked in the following procedures. Before performing the procedures, make sure anything which may touch the manipulator is not located in the operating range.

1. Adjust the manipulator’s posture to make the sensor flange side face to the ground and to make T-axis become the home position. After adjusting the posture, turn OFF the servo power.

Fig. 2-4: Posture to Confirm the Direction of the Sensor

2. By referring to “DX200/FS100 OPTIONS INSTRUCTIONS For MotoFit Function Engineering Support Tool (HW1481731) 3.1 Initial Settings”, install the MotoFit engineering support tool to the PC for teaching. Connect the PC to the DX200/FS100 by the LAN cable.

3. By referring to “DX200/FS100 OPTIONS INSTRUCTIONS For MotoFit Function Engineering Support Tool (HW1481731) 3.2.2.1 Startup of FSE-Tool”, start up the MotoFit engineering support tool.

4. Click “Monitor”.

5. Click “R1” or “R2” depending on the manipulator to which the force sensor is mounted, and then click (Start monitoring).
6. Check the robot coordinate direction of the manipulator to which the force sensor is mounted. As shown in the following figure, press the sensor with light force to make the force to be applied in the minus direction of the x-axis. The pressing position is the part below the gasket.

Fig. 2-5: Pressing Position of Sensor

7. Click “Stop monitoring” of the engineering tool.
2. Set Up of MotoFit Function
2.3 Operation Check

8. Check the “Force” graph on the upper right side of the engineering tool window. If the value is located in the minus direction of the Ffb(X) graph as shown in the following figure, the mounting is successfully completed.

*Fig. 2-6: Mounting Successful*

9. If the value is located in the plus direction of the Ffb(X) graph or the graph is not shown, the direction or the procedures for the mounting may be wrong.

*Fig. 2-7: Mounting Failed*

The value of the “Force” graph must be located in the minus direction of the graph. Make sure the procedures are properly performed depending on the following two cases.

The value of the “Force” graph is located in the plus direction of the graph.

- Make sure the force sensor is mounted as shown in the dimension diagram.(refer to chapter 2.1 “Mounting the 6-axis Force Sensor”)
- Make sure all the procedures explained up to the previous chapters are properly performed.

The graph is not shown.

- Make sure the communication port of the force sensor board is valid.(refer to chapter 6.2.2 “Enabling the Force Sensor”)
- Make sure all the procedures explained up to the previous chapters are properly performed.
3 Commands for MotoFit Function

The MotoFit function uses the following four special commands suitable for the fitting precision parts for a clearance from 10 \( \mu \text{m} \) to 100 \( \mu \text{m} \).

- **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)**

TOUCH, FIT, and INSERT are the command packaging multiple operations for precision fitting. On the other hand, the force sensor basic command is the command targeting relatively simple work (e.g. pressing with constant force, stopping the operation when detecting force which exceeds a specified force, etc.).

Table 3-1: Function Outline for Each Command

<table>
<thead>
<tr>
<th>Name</th>
<th>IMPO</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>

Table 3-1: Function Outline for Each Command

<table>
<thead>
<tr>
<th>Figure</th>
<th>Robot arm head Force sensor Tool</th>
<th>Robot arm head Force sensor Tool</th>
<th>Robot arm head Force sensor Tool</th>
<th>Robot arm head Force sensor Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>External force</td>
<td>Move according to an external force.</td>
<td>External force</td>
<td>Does not move</td>
<td>Press against the workpiece with the specified force.</td>
</tr>
</tbody>
</table>

Figure
3 Commands for MotoFit Function
3.1 Force Condition File

3.1 Force Condition File

In order to use the MotoFit function and force sense basic commands, it is necessary to set the force condition file.

*Table 3-2: Setting Items Force Condition File*

<table>
<thead>
<tr>
<th>Item</th>
<th>Setting range</th>
<th>Overview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robot</td>
<td>R1,R2</td>
<td>Specify the robot that execute MotoFit function or force sensor basic command.</td>
</tr>
<tr>
<td>Coordinate system</td>
<td>Robot, Tool</td>
<td>Specify the coordinate system that execute MotoFit function or force sensor basic command.</td>
</tr>
<tr>
<td>Fit direction</td>
<td>X+,X-,Y+,Y-,Z+,Z-</td>
<td>Specify the fit direction that execute MotoFit function.</td>
</tr>
<tr>
<td>Valid axes</td>
<td>X,Y,Z,Rx,Ry,Rz</td>
<td>Specify the force control valid axes. MotoFit function and copying motions by IMPON command, FREF command execute to specify the only valid axes.</td>
</tr>
</tbody>
</table>

For the procedure to set the force condition file, refer to “OPTIONS INSTRUCTIONS for MotoFit Function Engineering Support Tool”.

Control point for executing the MotoFit function, force sensor basic command fixed by tools selected during operation.
3.2 IMPOFF

3.2.1 Details of 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"`

3.2.2 Registration of 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” is shown on the input buffer line.
3.2 IMPOFF

(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 open the DETAIL EDIT window.
   – Put the cursor on “COMMAND” of SKILL COMMAND, and press [SELECT]. Here, input “IOF” in the input dialog box.

(5) Press [ENTER].
   – The DETAIL EDIT window is closed and the JOB CONTENT window is shown.

(6) Press [ADD], and press [ENTER].
   – The command shown on the input buffer line is registered.
3 Commands for MotoFit Function
3.3 TOUCH

3.3 TOUCH

3.3.1 Details of 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]
3 Commands for MotoFit Function

3.3 TOUCH

3.3.2 Registration of 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 is shown.

(3) Select the {SKILLSND} command.

– The SKILLSND “COMMAND” is shown on the input buffer line.

Table 3-3: 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 ¹</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>Lapproach</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>

¹ When the payload of the robot is under 9kg, setting range is limited to payload.
e.g. MH5II (payload : 5kg), setting range is 0 to 500[0.1N]
3 Commands for MotoFit Function
3.3 TOUCH

(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 “SKILLSND” command on the input buffer line, and press [SELECT] to open the DETAIL EDIT window.
- Put the cursor on “COMMAND” of SKILL COMMAND, and press [SELECT].
Here, input “TCH:1:10:5:5:10:3:1” in the input dialog box.

(5) Press [ENTER].
- The DETAIL EDIT window is closed and the JOB CONTENT window is shown.

(6) Press [ADD], and press [ENTER].
- The command shown on the input buffer line is registered.
3 Commands for MotoFit Function
3.4 FIT

3.4 FIT

3.4.1 Details of 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 8024 “FIT command execution step error” occurs.

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

<table>
<thead>
<tr>
<th>Force condition file number (FileNum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sets the number of the force control condition file.</td>
</tr>
<tr>
<td>Setting range: 1 to 24</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Force command value (Fpush)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sets the force command value. This is the command value of the force in the manipulator's advancement direction.</td>
</tr>
<tr>
<td>Setting range: 0 to 999, Unit: [0.1 N]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Insertion length threshold (Lins)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sets the insertion length threshold.</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>Setting range: 0 to 999, Unit: [0.1 mm]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Search operation pattern (Ptn_search)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sets the search operation pattern.</td>
</tr>
<tr>
<td>“0: XYZ” executes a reciprocating search operation in one of X-axis, Y-axis, and Z-axis directions (specified in ( \text{Ptn} ) later).</td>
</tr>
<tr>
<td>“1: ROTATE” executes a rotating search operation in one of X-axis, Y-axis, and Z-axis rotational directions.</td>
</tr>
<tr>
<td>“2: OMNI” executes a reciprocating search operation, changing its search direction by a certain angle.</td>
</tr>
<tr>
<td>Setting range: 0 to 2 (0: XYZ, 1: ROTATE, 2: OMNI)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Search force command value (Fsearch) or Search moment command value (Msearch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sets the command value of the force (or moment) in the search direction.</td>
</tr>
<tr>
<td>&lt;When “0: XYZ” or “2: OMNI” is set in the above ( \text{Ptn} ) &gt;</td>
</tr>
<tr>
<td>Setting range: 0 to 999, Unit: [0.1 N]</td>
</tr>
</tbody>
</table>

3.4 FIT

<When "1: ROTATE" is set in the above②>
Setting range: 0 to 99, Unit: [0.1 Nm]

<For the 200N sensor>
Setting range: 0~40, Unit: [0.1Nm]

6. Search vibration cycle (Cycle_search)
Sets the vibration cycle of the search operation.
Setting range: 2 to 999, Unit: [ms]

7. Search axial direction designation (Dir_search)
Selects the axial direction of the search operation.

<When "0: XYZ" or "2: OMNI" is set in the above④>
Set the direction to start the vibration of the search operation.

<When "2: ROTATE" is set in the above④>
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-)

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

<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 ¹</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 ¹</td>
<td>0.1 N</td>
</tr>
<tr>
<td></td>
<td>Search moment command value</td>
<td>Msearch</td>
<td>0 to 99</td>
<td>0.1 Nm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0 to 40 (for 200N sensor)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Search vibration cycle</td>
<td>Cycle_search</td>
<td>2 to 999</td>
<td>ms</td>
</tr>
<tr>
<td>7</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>8</td>
<td>Search operation time</td>
<td>Tsearch</td>
<td>0 to 999</td>
<td>0.1 s</td>
</tr>
</tbody>
</table>

¹ When the payload of the robot is under 9kg, setting range is limited to payload.
e.g. MH5II (payload : 5kg), setting range is 0 to 500[0.1N]
3.4.2 Registration of 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 is shown.

(3) Select the {SKILLSND} command.

– The SKILLSND “COMMAND” is shown 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 open the DETAIL EDIT window.

– Put the cursor on “COMMAND” of SKILL COMMAND, and press [SELECT]. Here, input “FIT:1:10:3:2:2:250:4:3” in the input dialog box.

(5) Press [ENTER].

– The DETAIL EDIT window is closed and the JOB CONTENT window is shown.

(6) Press [ADD], and press [ENTER].

– The command shown on the input buffer line is registered.
3 Commands for MotoFit Function
3.5 INSERT

3.5 INSERT

3.5.1 Details of 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 8024 “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:

   \[ Lins1 < (Insertion length command) < Lins2 \]

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

4. Insertion length threshold (Lins2)
   Sets the insertion length threshold. In the INSERT command, “Lin2” 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:

   \[ Lins1 < (Insertion length command) < Lins2 \]

   Setting range: 0 to 999, Unit: [0.1 mm]
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. Input any values within the range in 6 to 9. It does not affect the 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

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.

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

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.

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

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.

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

Unchoke operation time (Tins)

Sets the search operation execution time in the unchoke operation when “1” or “2” is set in the former 5.

Setting range: 0 to 999, Unit: [0.1 s]
# 3 Commands for MotoFit Function

## 3.5 INSERT

Table 3-5: 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(^1)</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>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>9</td>
<td>Unchoke operation time</td>
<td>Tins</td>
<td>0 to 999</td>
<td>0.1 s</td>
</tr>
</tbody>
</table>

\(^1\) When the payload of the robot is under 9kg, setting range is limited to payload.

* e.g. MH5II (payload : 5kg), setting range is 0 to 500[0.1N]
3.5.2 Registration of INSERT

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

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

(3) Select the {SKILLSND} command.
   - The SKILLSND “COMMAND” is shown 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 “SKILLSND” command on the input buffer line, and press [SELECT] to open the DETAIL EDIT window.

(5) Press [ENTER].
   - The DETAIL EDIT window is closed and the JOB CONTENT window is shown.

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

3.6.1 Details of IMPON

IMPON is a command that resets the force sensor value to zero and sets the force control state.

In the force control state, 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.

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

2. FORCE-CONTROL
   - This is the option to enable/disable the force control.
   - If “1” is set in the “FILE_NO”, the force control is invalid and the manipulator does not move according to the external force.
   - This option must be used only when the measuring in position control by the force sensor is performed.
   - Setting range: 0 to 1
     - 0: Force control valid
     - 1: Force control invalid. The measuring of the force is executed

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.
   - Setting range: 0 to 1
     - 0: valid
     - 1: invalid
Table 3-6: 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 OFFSET</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>

**Usage example of IMPON parameter, **②**FORCE CONTROL** and ③**OFFSET**.

When the tool is moved toward the target to touch, the following operations are possible. The position control which is performed until the tool touches the target and the force control which starts when the touch is detected.

For the force detection or the pressing operation with the constant force, the Macro instruction which is explained later is used.

*Fig. 3-1: IMPON*

Moves toward the touching target by position control
- IMPON ②FORFORCE-CONTROL=1 ③OFFSET=0

Force control starts when the touch is detected
- Sensor is not reset
- IMPON ②FORCE-CONTROL=0 ③OFFSET=1

Moves while pressing with constant force
3.6.2 Registration of IMPON

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 is shown.

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

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

5. Press [ENTER].
   - The ARGUMENT SETTING window is closed and the JOB CONTENT window is shown.

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

3.7.1 Details of 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.

1. **FREF-X**
   Set the force command value for the X direction.
   Setting range: payload of the robot, Unit: [N]

2. **FREF-Y**
   Set the force command value for the Y direction.
   Setting range: payload of the robot, Unit: [N]

3. **FREF-Z**
   Set the force command value for the Z direction.
   Setting range: payload of the robot, Unit: [N]
3 Commands for MotoFit Function
3.7 FREF (Macro Instruction)

4 FREF-RX
Set the force command value for the RX direction.
Setting range: sensor rating, Unit: \([0.01 \text{N} \cdot \text{m}]^2\)

5 FREF-RY
Set the force command value for the RY direction.
Setting range: sensor rating, Unit: \([0.01 \text{N} \cdot \text{m}]^2\)

6 FREF-RZ
Set the force command value for the RZ direction.
Setting range: sensor rating, Unit: \([0.01 \text{N} \cdot \text{m}]^2\)

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 3-7: 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>payload of the robot(^1)</td>
<td>N</td>
</tr>
<tr>
<td>2</td>
<td>Force command value for the Y direction</td>
<td>FREF-Y</td>
<td>payload of the robot(^1)</td>
<td>N</td>
</tr>
<tr>
<td>3</td>
<td>Force command value for the Z direction</td>
<td>FREF-Z</td>
<td>payload of the robot(^1)</td>
<td>N</td>
</tr>
<tr>
<td>4</td>
<td>Force command value for the RX direction</td>
<td>FREF-RX</td>
<td>sensor rating(^2)</td>
<td>0.01N-m</td>
</tr>
<tr>
<td>5</td>
<td>Force command value for the RY direction</td>
<td>FREF-RY</td>
<td>sensor rating(^2)</td>
<td>0.01N-m</td>
</tr>
<tr>
<td>6</td>
<td>Force command value for the RZ direction</td>
<td>FREF-RZ</td>
<td>sensor rating(^2)</td>
<td>0.01N-m</td>
</tr>
<tr>
<td>7</td>
<td>UNTIL enable or disable specification</td>
<td>UNTIL</td>
<td>0 to 1</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>Timeout error check time</td>
<td>TIMEOUT</td>
<td>0 to 2147483647</td>
<td>ms</td>
</tr>
</tbody>
</table>

---

1 Setting range is limited to payload.
e.g. MH12 (payload : 12kg), setting range is -120 to 120[0.1N]

2 Setting range is limited to sensor rating.
e.g. Rated moment 30Nm force sensor, setting range is -3000 to 3000[0.01Nm]
3.7 FREF (Macro Instruction)

3.7.2 Registration of 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 is shown.

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

4. Set the parameter for the FREF command in the ARGUMENT SETTING window is shown.

5. Press [ENTER].
   – The ARGUMENT SETTING window is closed and the JOB CONTENT window is shown.

6. Press [ADD], and press [ENTER].
   – The command shown on the input buffer line is registered.
3 Commands for MotoFit Function
3.8 FDET (Macro Instruction)

3.8 FDET (Macro Instruction)

3.8.1 Details of 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.

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

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 MotoFit Function
3.8 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]

*Alarm 8009 (abnormality outside the argument range) occurs when each setting value of ② to ⑨ goes High < Low.

<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 MotoFit Function
3.8 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 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 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 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 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 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 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

*Alarm 8009 (abnormality outside the argument range) occurs when each setting value of ② to ⑨ goes High < Low.
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 3-8: 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>Force 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>Impulse 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. 3-2 “Impulse”. The advantage of using impulse is shown in table 3-9 “Advantage of Impulse”. If not detecting relatively small force, select force detection.

**Fig. 3-2: Impulse**

![Impulse Diagram]

**Table 3-9: Advantage of Impulse**

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Reference diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  The momentary force change caused by noise or an operation has small affection to the impulse change.</td>
<td><img src="https://example.com" alt="Reference Diagram 1" /></td>
</tr>
<tr>
<td>2  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="https://example.com" alt="Reference Diagram 2" /></td>
</tr>
</tbody>
</table>
### Direction of the force detection

In the coordinate system (the robot coordinate system or the tool coordinate system) which is set in the force condition file, confirm the direction in which the external force is applied on the tool.

The following is the example of the robot coordinate system.

*Fig. 3-3: Direction of External Force*

The force is applied on the tool in the Z+ direction. When the external force is 10N, the force is detected if the threshold value is under 10 (9 or 8).

The force is applied on the tool in the X-direction. When the external force is 10N, the force is detected if the threshold value is above -10 (-9 or -8).
3.8 FDET (Macro Instruction)

3.8.2 Registration of 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 is shown.

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

   – The ARGUMENT SETTING window is shown.

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

5. Press [ENTER].

   – The ARGUMENT SETTING window is closed and the JOB CONTENT window is shown.

6. Press [ADD], and press [ENTER].

   – The command shown on the input buffer line is registered.
3.9 IMPOFF (Macro Instruction)

3.9.1 Details of 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 chapter 3.2 “IMPOFF”.

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

3.9.2 Registration of 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 is shown.

3. Select {IMPOFF-R1} command (In case of dual-arm robot's R-arm, select {IMPOFF-R2} command).
   – “IMPOFFR1” (or “IMPOFFR2”) is shown on the input buffer line.

4. Press [ADD], and press [ENTER].
The command shown on the input buffer line is registered.
3 Commands for MotoFit Function

3.10 RESCALE (FS100 only)

3.10.1 Details of RESCALE

RESCALE is a command that changes parameter units relevant to force or length for the whole MotoFit function commands.

The command is expressed with "RESCALE" as shown below, and it is followed by the parameter.

```
SKILLSND "RESCALE: ① : ②"
```

① Unit to be changed (Unit)
   - Set units to be changed with this command.
   - Setting value: 1, 2 (1: N,Nm, Ns, 2: mm)

② Scale to be changed (Scale)
   - The scale is designated with the power of 10.
   - Setting range: -2 to 1

Following shows an example of this command.

NOP
SKILLSND "RESCALE: 0 : -1 " Force-relevant unit change (×10⁻¹)
MOVL V=50.0 Moves to job start point
SKILLSND"TCH:1:250:40;300:10:100:10" Touch workpieces
   (Force threshold • Command value ×0.01N)
SKILLSND"FIT:1:400:5:2:600:300:2:200" Hole search operation
   (Force command value×0.01N)
   (Force command value×0.01N)
IMPOFF Force controle complete (Unit change complete)
IMOV P001 V=50.0 Retract
END
3.10.2 Registration of RESCALE

1. Move the cursor to the line just above the position to which “RESCALE” is intended to be registered.

2. Press [COMMAND LIST], and press {OTHER}.
   - The COMMAND LIST dialog is shown.

3. Select the {SKILLSND} command.
   - The SKILLSND “COMMAND” is shown on the input buffer line.

4. Input a command as the parameter.
   (Here, input “RESCALE:1:-1” as an example.)
   - Put the cursor on the “SKILLSND” command on the input buffer line, and press [SELECT] to display the DETAIL EDIT window.
   - Put the cursor on “COMMAND” of SKILL COMMAND, and press [SELECT].
     Here, input “RESCALE:1:-1” in the input dialog box.

5. Press [ENTER].
   - The DETAIL EDIT window is closed and the JOB CONTENT window is shown.

6. Press [ADD], and press [ENTER].
   - The command shown on the input buffer line is registered.
4 Example for Creating MotoFit JOB

The following explains the procedure to create a JOB for the usage example of MotoFit which is shown in chapter 1.3 “Usage Example of MotoFit Function”.

Be sure that the setting value of the command or the procedure to create a JOB is different depending on the hand or the workpiece.

When the force control is performed by using the MotoFit function, it is necessary to set the force condition file. For the procedure to set the force condition file, refer to “OPTIONS INSTRUCTIONS for MotoFit Function Engineering Support Tool”.

The hand must have the structure which can hold a workpiece firmly. If a workpiece slips from the hand during the operation and changes its position relative to the hand, the workpiece may not fit to its mating part as instructed.

The workpiece and the hand must not change their shapes during the operation. If the workpiece has a shape which can be easily changed, the operation may not be performed as instructed.

4.1 Fitting Operation for Cylindrical Workpiece

The example of fitting operation for cylindrical workpiece as shown in the following figure is explained.

Fig. 4-1: Fitting Operation for Workpiece
4.1.1 Procedure to Create the fitting JOB

For the fitting operation, a JOB can be easily created by the “Guidance Menu” of the MotoFit Function Engineering Support Tool. This chapter explains the summary. For the details of using the engineering support tool, refer to “DX200/FS100 OPTIONS INSTRUCTIONS for MotoFit Function Engineering Support Tool (HW1481731)”.

1. When the MotoFit Function Engineering Support Tool is started up on the PC for teaching, the “Setting Force Condition File” window is shown. By referring to “Guidance Menu”, select the force condition file No. (No. 1 is selected in the example). Click (Receive) and set the following items.

   Robot: select the robot to use
   (R1 is selected in the example)

   Coordinate: select the coordinate system to use
   (Robot is selected in the example)

   Tool No.: select the tool information number that gripped the workpiece
   (No.0 is selected in the example)

   Insertion direction: (Z- is selected in the example)

   Force control enable/disable (valid axes): select the axis in which the force control is valid. Not only the fitting direction but also the direction of axis for searching hole are valid (the X, Y, Z-axes are selected in the example)

   ![Image of MotoFit Function Engineering Support Tool]

   The tool information must be registered while the workpiece is being held. The held workpiece and the hand are calculated and tuned as one rigid body. If the workpiece is not being held, the force condition for the fitting operation is different and the operation may be difficult.
4. Example for Creating MotoFit JOB

4.1 Fitting Operation for Cylindrical Workpiece

2. In the "Force Control Parameters Auto Tuning Menu", in accordance with the "Guidance Menu", the tuning operation of the parameters must be performed for the axes which are selected as valid axes. For the tuning direction, either "+" or "-" must be selected for each axes.

3. After the force condition file is transmitted to the DX200/FS100, select the "Creating MotoFit JOB" to open the "MotoFit Command Setup Menu". The parameters of the fitting JOB must be tuned in accordance with the "Guidance Menu".
4. Example for Creating MotoFit JOB
4.1 Fitting Operation for Cylindrical Workpiece

4. After tuning the parameters of the fitting JOB, the JOB must be transmitted to the DX200/FS100 in accordance with the “Guidance Menu” in the following window. The JOB is created in the DX200/FS100.

4.1.2 Example of Fitting JOB

The example of the JOB are shown in the following table. The numbers in the first column from the left side correspond to the numbers of the operation example in chapter 4.1.3.

If a JOB is created according to the example of procedures explained in the previous chapter, the instructions of the job line from no.0003 to no.0020 are registered. The waiting position or the retraction must be set depending on the situation.
### 4 Example for Creating MotoFit JOB

#### 4.1 Fitting Operation for Cylindrical Workpiece

<table>
<thead>
<tr>
<th>No.</th>
<th>Job line No.</th>
<th>Command</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0001</td>
<td>MOVJ MJ=10.0</td>
<td>Moves to waiting position.</td>
</tr>
<tr>
<td>2</td>
<td>0002</td>
<td>MOVJ MJ=50.0</td>
<td>Moves to job start point.</td>
</tr>
<tr>
<td></td>
<td>0003</td>
<td>SET B098 0</td>
<td>Set 0 in B098</td>
</tr>
<tr>
<td></td>
<td>0004</td>
<td>SET B099 0</td>
<td>Set 0 in B099</td>
</tr>
<tr>
<td>3</td>
<td>0005</td>
<td>SKILLSND  &quot;TCH:1:10:40:10:100:10&quot;</td>
<td>Makes the workpiece touch the mating part.</td>
</tr>
<tr>
<td>4</td>
<td>0006</td>
<td>WAIT OT#(1012)=ON</td>
<td>Wait until the FIT command (TOUCH) execution completion signal (general output signal No.: 1012) is output.</td>
</tr>
<tr>
<td>5</td>
<td>0007</td>
<td>SKILLSND  &quot;FIT:1:70:5:2:200:300:2:200&quot;</td>
<td>Hole search operation</td>
</tr>
<tr>
<td>6</td>
<td>0008</td>
<td>WAIT OT#(1013)=ON</td>
<td>Wait until the FIT command (FIT) execution completion signal (general output signal No.: 1013) is output.</td>
</tr>
<tr>
<td></td>
<td>0009</td>
<td>DIN B098 OT#(1010)</td>
<td>The FIT command (FIT) success signal (general output signal No.: 1010) is stored in B098.</td>
</tr>
<tr>
<td></td>
<td>0010</td>
<td>JUMP *NG IF B098=0</td>
<td>Jumps to the label *NG if B098=0 (FIT failed)</td>
</tr>
<tr>
<td>7</td>
<td>0011</td>
<td>SKILLSND  &quot;INS:1:300:180:210:1:8:70:2:20&quot;</td>
<td>Workpiece insertion operation</td>
</tr>
<tr>
<td>8</td>
<td>0012</td>
<td>WAIT OT#(1014)=ON</td>
<td>Wait until the FIT command (INSERT) execution completion signal (general output signal No.: 1014) is output.</td>
</tr>
<tr>
<td></td>
<td>0013</td>
<td>DIN B099 OT#(1011)</td>
<td>The FIT command (INSERT) success signal (general output signal No.: 1011) is stored in B099.</td>
</tr>
<tr>
<td></td>
<td>0014</td>
<td>JUMP *NG IF B099=0</td>
<td>Jumps to the label *NG if B099=0 (FIT failed)</td>
</tr>
<tr>
<td></td>
<td>0015</td>
<td>JUMP *OK</td>
<td>Jumps to the label *OK</td>
</tr>
<tr>
<td></td>
<td>0016</td>
<td>*NG</td>
<td>The label *NG</td>
</tr>
<tr>
<td></td>
<td>0017</td>
<td>SKILLSND &quot;IOF&quot;</td>
<td>Force control ends.</td>
</tr>
<tr>
<td></td>
<td>0018</td>
<td>PAUSE</td>
<td>JOB is stopped</td>
</tr>
<tr>
<td>9</td>
<td>0019</td>
<td>*OK</td>
<td>The label *OK</td>
</tr>
<tr>
<td></td>
<td>0020</td>
<td>SKILLSND &quot;IOF&quot;</td>
<td>Force control ends.</td>
</tr>
<tr>
<td>10</td>
<td>0021</td>
<td>DOUT OT#(1) ON</td>
<td>Releases the workpiece when the hand open/close signal allocation is OT#(1)</td>
</tr>
</tbody>
</table>
|     | 0022         | IMOV P001 V50.0 | Retraction  
Note: With the IMOV instruction, the linear interpolation motion is performed in which the manipulator moves from the current position as far as the increment value.  
For details, refer to "FS100 OPTIONS INSTRUCTIONS FOR INFORM LANGUAGE (RE-CKI-A458)" or "DX200 OPTIONS INSTRUCTIONS FOR INFORM LANGUAGE (RE-CKI-A464)" |

*Variables B098, B099 can be changed arbitrarily.*
4.1.3 Operation Example of The Fitting JOB

1. Holds a workpiece and moves to the waiting position.
2. With the workpiece held, moves to the job start point.

*Fig. 4-2: Job Start Point*

3. The force control starts by the TOUCH command to make the workpiece touch the mating part.

*Fig. 4-3: Touch Point*

4. Waits until the workpiece touches the mating part and the job completion signal is output.
5. Executes the hole search operation by the FIT command.

*Fig. 4-4: Search for the Hole Position*

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

7. Executes the workpiece insert operation by the INSERT command.

*Fig. 4-5: Insert*

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

9. The force control ends and the normal operation by the position control is restored.
10. Releases the workpiece and retracts.

*Fig. 4-6: Retract*
4.2 Applying Tape

The following figure shows an example of work for applying tape to a plate. This explanation is on the assumption that R1 is used and the force control is performed in the robot coordinate system.

**Fig. 4-7: Applying Tape**

4.2.1 Procedure to Create JOB for Applying Tape

1. When the MotoFit Function Engineering Support Tool is started up on the PC for teaching, the “Setting Force Condition File” window is shown.
   By referring to the “Guidance Menu”, select the force condition file No. (No.1 is selected in the example). Click {Receive} and set the following items.

   - **Robot**: select R1
   - **Coordinate**: select the Robot
   - **Tool No.**: select the tool information number.
   - **Force control enable/disable (valid axes)**: valid. Not only the pressing direction but also the axis for the force detection are valid (the X,Z-axes are selected in the example).
4. Example for Creating MotoFit JOB

4.2 Applying Tape

2. In the “Force Control Parameters Auto Tuning Menu”, by referring to the “Guidance Menu”, the tuning operation of the parameters must be performed for the axes which are selected as valid axes. For the tuning direction, either “+” or “-” must be selected for each axes.

3. Transmit the force condition file to the DX200/FS100.
4. Register the initial position.

*Fig. 4-8: Initial Position*

5. Input the “IMPON-R1” in the Macro instruction. Set the arguments as the following.

- **FILE_NO:** select the force condition file No. which is set in the previous procedure (No.1 is selected in the example)
- **FORCE-CONTROL:** 0 (The force control valid)
- **OFFSET:** 0 (The sensor reset is executed by this instruction)

6. Input the “FREF-R1” in the Macro instruction. Set the arguments as the following.

- **FREF-X/FREF-Y:** 0
- **FREF-Z:** -10 (For the pressing downward operation with 10N force, the direction is Z- in the robot coordinate and input -10)
- **OFFSET:** 0 (The sensor reset is executed by this instruction)
- **FREF-RX/FREF-RY/FREF-RZ:** 0
- **UNTIL:** 0
- **TIMEOUT:** 3000 (After the pressing operation is performed for 3 seconds, the instruction of the next JOB line is executed. The pressing operation continues)
4. Example for Creating MotoFit JOB

4.2 Applying Tape

7. Input the “FDET-R1” in the Macro instruction. Set the arguments as the following.

   METHOD: 1 (Force detection)
   THRESHOLD-XHIGH: 0
   THRESHOLD-XLOW: -15 (If the direction of travel is the X+ direction, a minus value is set since the force is applied in the X-direction due to the obstacles
   THRESHOLD-YHIGH/LOW, ZHIGH/LOW: 0
   TIME: 500 (It is judged as the detection if the 15N force is applied in the X-direction for 500ms.)

8. Register the end position. If the general input is ON for UNTIL, the operation is stopped. The general input number is 990 for R1, 992 for R2.

9. Input the “IMPOFFR1” in the Macro instruction.

4.2.2 Example of JOB for Applying Tape

The example of the JOB are shown in the following table. The numbers in the first column from the left side correspond to the numbers of the operation example in the next chapter.

<table>
<thead>
<tr>
<th>No.</th>
<th>Job line No.</th>
<th>Command</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0001</td>
<td>MOV L V=50.0</td>
<td>Moves to the initial position.</td>
</tr>
<tr>
<td>2</td>
<td>0002</td>
<td>IMPON-R1 (FILE_NO:1, FORCE-CONTROL : 0 OFFSET: 0)</td>
<td>Force control starts.</td>
</tr>
<tr>
<td>3</td>
<td>0003</td>
<td>FREF-R1 (FREF-X,Y,RX,RY,RZ:0 FREF-Z: -10 UNTIL: 0 TIMEOUT: 3000</td>
<td>Performs the pressing operation with 10N force in the Z-direction of the robot coordinate for 3 seconds.</td>
</tr>
<tr>
<td>4</td>
<td>0004</td>
<td>FDET-R1 (METHOD:1 THRESHOLD-XHIGH: 0 THRESHOLD-XLOW: -15 THRESHOLD-YHIGH/LOW, ZHIGH/LOW: 0 TIME: 500)</td>
<td>It is judged as the detection if the 15N force is applied in the X-direction for 500ms</td>
</tr>
<tr>
<td>5</td>
<td>0005</td>
<td>MOV L V=20.0 PL=0 UNTIL IN#(991)=ON</td>
<td>Moves to the end position. If the force is detected by FDET during operation, the operation is stopped.</td>
</tr>
<tr>
<td>6</td>
<td>0006</td>
<td>IMPOFFR1</td>
<td>Force control ends.</td>
</tr>
</tbody>
</table>
4.2.3 Operation Example of JOB for Applying Tape

1. Moves to the initial position.

*Fig. 4-9: Initial Position*

2. The force control starts.

3. Performs the pressing with 10N force in the Z-direction of the robot coordinate for 3 seconds.

*Fig. 4-10: Pressing*

4. The force detection of the X-axis direction starts.

5. Moves to the end position. The operation is stopped if the force of the X-axis direction is detected by FDET during the movement.

6. If the force of the X-axis direction is not detected by FDET and the robot arm moves to the end position, the force control ends.

*Fig. 4-11: End Position*
4.3 Polishing Operation

The example of the side polishing for the cylindrical workpiece as shown in the following figure is explained. This explanation is on the assumption that R1 is used and the force control is performed in the tool coordinate system.

Fig. 4-12: Polishing Operation

4.3.1 Procedure to Create The Polishing JOB

1. When the MotoFit Function Engineering Support Tool is started up on the PC for teaching, the “Setting Force Condition File” window is shown. By referring to the “Guidance Menu”, select the force condition file No. (No.1 is selected in the example). Click {Receive} and set the following items.

   Robot: select R1

   Coordinate: select the tool

   Tool No.: select the tool information number. (No.0 is selected in the example)

   Force control enable/disable (valid axes): select the axis in which the force control is valid. The pressing direction is valid (the X-axis is selected in the example)
2. In the “Force Control Parameters Auto Tuning Menu”, by referring to the “Guidance Menu”, the tuning operation of the parameters must be performed for the axes which are selected as valid axes. For the tuning direction, either "+" or "-" must be selected for each axes.

3. Transmit the force condition file to the DX200/FS100.
4 Example for Creating MotoFit JOB
4.3 Polishing Operation

4. Register the initial position.
   The X-axis of the tool coordinate must be instructed to face to the center of the cylinder.

*Fig. 4-13: Initial Position*

5. Input the “IMPON-R1” in the Macro instruction. Set the arguments as the following.

   - FILE_NO: select the force condition file No. which is set in the previous procedure (No.1 is selected in the example)
   - FORCE-CONTROL: 0 (The force control valid)
   - OFFSET: 0 (The sensor reset is executed by this instruction)
   - FREF-X: 10 (Performs the pressing operation with 10N force in the X+ direction of the tool coordinate.)
   - UNTIL: 0
   - TIMEOUT: 3000

   (After the pressing operation is performed for 3 seconds, the instruction of the next JOB line is executed. The pressing operation continues)
4. Example for Creating MotoFit JOB

4.3 Polishing Operation

7. Register the teaching point along with the cylindrical surface. The X-axis of the tool coordinate must be taught to face to the center of the cylinder. It is not necessary that the tool and the workpiece touch each other. The standard of the teaching is one point per degree from 20° to 30°.

*Fig. 4-14: Teaching Point*

8. Input the “IMPOFFR1” in the Macro instruction.

9. Register the retraction point.

*Fig. 4-15: Retraction Point*
4.3.2 Example of Polishing JOB

The example of the JOB are shown in the following table. Leftmost number correspond to the numbers of the operation example in the chapter 4.3.3 “Operation Example of Polishing JOB”.

<table>
<thead>
<tr>
<th>No.</th>
<th>Job line No.</th>
<th>Command</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0001</td>
<td>MOV L V=100.0</td>
<td>Moves to the initial position.</td>
</tr>
<tr>
<td>2</td>
<td>0002</td>
<td>IMPON-R1 (FILE_NO:1, FORCE-CONTROL:0 OFFSET:0)</td>
<td>Force control starts.</td>
</tr>
<tr>
<td>3</td>
<td>0003</td>
<td>FREF-R1 (FREF-X:10,Y,Z,RX,RY,RZ:0 UNTIL:0 TIMEOUT:3000)</td>
<td>Performs the pressing operation with 10N force in the X+ direction of the robot coordinate for 3 seconds.</td>
</tr>
<tr>
<td>4</td>
<td>0004</td>
<td>MOV L V=50.0</td>
<td>Teaching point No.1 along with a cylindrical surface</td>
</tr>
<tr>
<td></td>
<td>0005</td>
<td>MOV L V=50.0</td>
<td>Teaching point No.2 along with a cylindrical surface</td>
</tr>
<tr>
<td></td>
<td>0006</td>
<td>MOV L V=50.0</td>
<td>Teaching point No.3 along with a cylindrical surface</td>
</tr>
<tr>
<td></td>
<td>0007</td>
<td>MOV L V=50.0</td>
<td>Teaching point No.4 along with a cylindrical surface</td>
</tr>
<tr>
<td></td>
<td>0008</td>
<td>MOV L V=50.0</td>
<td>Teaching point No.5 along with a cylindrical surface</td>
</tr>
<tr>
<td>5</td>
<td>0009</td>
<td>IMPOFFR1</td>
<td>Force control ends</td>
</tr>
<tr>
<td>6</td>
<td>0006</td>
<td>MOV L V=100.0</td>
<td>Moves to the retraction point</td>
</tr>
</tbody>
</table>

4.3.3 Operation Example of Polishing JOB

1. Moves to the initial position.
   
   Fig. 4-16: Initial Position

2. The force control starts.

3. Performs the pressing with 10N force in the Z-direction of the tool coordinate for 3 seconds.
4. Moves along with the cylindrical surface while pressing the tool against the workpiece.

*Fig. 4-17: Pressing*

5. Force control ends.

6. Moves to the retraction point.

*Fig. 4-18: Retraction Point*
5 Status Output Signal

5.1 Force Control Status Signal

The following shows the status signals of the force control. They are useful for the sequential control performed by user.

5.1.1 Special Output

The statuses which are output to the special output signals are shown in table 5-1 “Special Output of MotoFit Function”.

<table>
<thead>
<tr>
<th>Status</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impedance control proceeding (R1) 873</td>
<td>51100</td>
</tr>
<tr>
<td>Impedance control proceeding (R2) 874</td>
<td>51101</td>
</tr>
<tr>
<td>Inner force sensor offset value calculation complete</td>
<td>51110</td>
</tr>
<tr>
<td>Inner force sensor offset value calculation complete</td>
<td>51111</td>
</tr>
</tbody>
</table>

5.1.2 General Output

The statuses which are output to the general output signals are shown in table 5-2 “General Output of MotoFit Function”.

<table>
<thead>
<tr>
<th>Destination</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>OT# Logical No.</td>
<td></td>
</tr>
<tr>
<td>991 11246</td>
<td>FDET detection (R1)</td>
</tr>
<tr>
<td>992 11247</td>
<td>FDET detection (R2)</td>
</tr>
<tr>
<td>1009 11270</td>
<td>FIT command (TOUCH) successful (R1)</td>
</tr>
<tr>
<td>1010 11271</td>
<td>FIT command (FIT) successful (R1)</td>
</tr>
<tr>
<td>1011 11272</td>
<td>FIT command (INSERT) successful (R1)</td>
</tr>
<tr>
<td>1012 11273</td>
<td>FIT command (TOUCH) job end (R1)</td>
</tr>
<tr>
<td>1013 11274</td>
<td>FIT command (FIT) job end (R1)</td>
</tr>
<tr>
<td>1014 11275</td>
<td>FIT command (INSERT) job end (R1)</td>
</tr>
<tr>
<td>1017 11280</td>
<td>FIT command (TOUCH) successful (R2)</td>
</tr>
<tr>
<td>1018 11281</td>
<td>FIT command (FIT) successful (R2)</td>
</tr>
<tr>
<td>1019 11282</td>
<td>FIT command (INSERT) successful (R2)</td>
</tr>
<tr>
<td>1020 11283</td>
<td>FIT command (TOUCH) job end (R2)</td>
</tr>
<tr>
<td>1021 11284</td>
<td>FIT command (FIT) job end (R2)</td>
</tr>
<tr>
<td>1022 11285</td>
<td>FIT command (INSERT) job end (R2)</td>
</tr>
</tbody>
</table>
5.2 Registers Output Function (FS100)

This function supplies force and position information to the registers. With this function the force and position information are sent to the PLC device which is connected to FS100 by Fieldbus.

5.2.1 Setting of Registers Output Function

Supplying of force and position information to the registers starts after the trigger signal from PLC device is received by the FS100. Once the supplying starts, the FS100 sends back the measurement start signal to the PLC device.

Each signals are allocated as below.

Table 5-3: General Output of Registers Output Function

<table>
<thead>
<tr>
<th>General Input</th>
<th>General Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>#01280</td>
<td>Trigger signal from the PLC device</td>
</tr>
<tr>
<td>#11220</td>
<td>Start signal to the PLC device</td>
</tr>
</tbody>
</table>

Output function to the registers and coordinate system of force information can be chosen by allocating information to the pseudo input which are shown in the following table.

Table 5-4: Pseudo Input Signal of Registers Output Function

<table>
<thead>
<tr>
<th>Pseudo Input</th>
<th>OFF</th>
<th>ON</th>
</tr>
</thead>
<tbody>
<tr>
<td>#82170 Reg Output Func</td>
<td>With function</td>
<td>Without function</td>
</tr>
<tr>
<td>#82173 Frc FB Coord Sys</td>
<td>Robot Coordinate System</td>
<td>Tool Coordinate System</td>
</tr>
<tr>
<td>#82174 Frc FB</td>
<td>Not supplied</td>
<td>supplied</td>
</tr>
<tr>
<td>#82175 Frc CMD Value</td>
<td>Not supplied</td>
<td>supplied</td>
</tr>
<tr>
<td>#82176 Pos CMD Value</td>
<td>Not supplied</td>
<td>supplied</td>
</tr>
<tr>
<td>#82177 Pos FB</td>
<td>Not supplied</td>
<td>supplied</td>
</tr>
</tbody>
</table>
5 Status Output Signal
5.2 Registers Output Function (FS100)

Fig. 5-1: Pseudo Input Signal Window (Setting Conditions for Allocating Registers)

Cycle of function to the registers can be set up by allocating information to the pseudo input as shown in the following table.

<table>
<thead>
<tr>
<th>Cycle</th>
<th>#82187</th>
<th>#82186</th>
<th>#82185</th>
<th>#82184</th>
<th>#82183</th>
<th>#82182</th>
<th>#82181</th>
<th>#82180</th>
<th>Decimal</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>20ms</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>0</td>
<td>Default</td>
</tr>
<tr>
<td></td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>30ms</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>ON</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>40ms</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>to</td>
<td>to</td>
<td>to</td>
<td>to</td>
<td>to</td>
<td>to</td>
<td>to</td>
<td>to</td>
<td>to</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1280ms</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>128</td>
<td></td>
</tr>
<tr>
<td>to</td>
<td>to</td>
<td>to</td>
<td>to</td>
<td>to</td>
<td>to</td>
<td>to</td>
<td>to</td>
<td>to</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2540ms</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
<td>OFF</td>
<td>254</td>
<td></td>
</tr>
<tr>
<td>2550ms</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
<td>255</td>
<td></td>
</tr>
</tbody>
</table>

Note) The cycle is only showing of its standard. There is no guarantee of its updating cycle. The minimum cycle is 20ms.
5.2 Registers Output Function (FS100)

Fig. 5-2: Pseudo Input Signal Window (Setting for Data Updating Cycle)

5.2.2 Registers as Destination of Allocation and Data Type

Registers to which the force and the position information are allocated are shown in Table 5-5 "Registers as Destination of Allocation".

Table 5-5: Registers as Destination of Allocation

<table>
<thead>
<tr>
<th>M509</th>
<th>M508</th>
<th>M507</th>
<th>M506</th>
<th>M505</th>
<th>M504</th>
<th>M503</th>
<th>M502</th>
<th>M501</th>
<th>M500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>X</td>
<td>The first axis</td>
<td>E</td>
<td>Rz</td>
<td>Ry</td>
<td>Rx</td>
<td>Z</td>
<td>Y</td>
<td>X</td>
</tr>
<tr>
<td>M519</td>
<td>M518</td>
<td>M517</td>
<td>M516</td>
<td>M515</td>
<td>M514</td>
<td>M513</td>
<td>M512</td>
<td>M511</td>
<td>M510</td>
</tr>
<tr>
<td>FB (R1)</td>
<td>FB (R1)</td>
<td>FB (R1)</td>
<td>FB (R2)</td>
<td>Position Command (B2)</td>
<td>The first axis</td>
<td>E</td>
<td>Rz</td>
<td>Ry</td>
<td>Rx</td>
</tr>
<tr>
<td>RX</td>
<td>Z</td>
<td>Y</td>
<td>X</td>
<td>M529</td>
<td>M528</td>
<td>M527</td>
<td>M526</td>
<td>M525</td>
<td>M524</td>
</tr>
<tr>
<td>FB (R2)</td>
<td>FB (R2)</td>
<td>FB (R2)</td>
<td>FB (R2)</td>
<td>FB (R2)</td>
<td>FB (R2)</td>
<td>FB (R2)</td>
<td>FB (B1)</td>
<td>FB (R1)</td>
<td>FB (R1)</td>
</tr>
</tbody>
</table>
5 Status Output Signal
5.2 Registers Output Function (FS100)

Note: FB, R1 and R2 stand for feedback, Robot1 and Robot2.

The following shows the unit of output data.

<table>
<thead>
<tr>
<th>Data</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position info (X,Y,Z)</td>
<td>0.1mm</td>
</tr>
<tr>
<td>Rotation angle info (Rx, Ry, Rz)</td>
<td>0.01deg</td>
</tr>
<tr>
<td>Force info (Fx, Fy, Fz)</td>
<td>0.1N</td>
</tr>
<tr>
<td>Moment info (Mx,My,Mz)</td>
<td>0.1Nm</td>
</tr>
</tbody>
</table>

For the register output function, data units are expressed in 16 bits and negative values are expressed in two's complement. The operation must be performed as shown in the following two example.

1) The force information is shown as 150 in the register.
   
   150 (register value) -> 15N

2) The force information is shown as 65386 in the register.
   
   65386 (register value) -> 65385 (one's complement) -> -1x150 (bit inversion) -> -15N
5 Status Output Signal
5.3 Registers Output Function (DX200)

5.3 Registers Output Function (DX200)

5.3.1 Overview

Output information of force sensor to registers. With this function, force information can be sent to external PLC etc. Output specifications are shown in table 5-6 “Output specification”. The cycle is only showing of its standard. There is no guarantee of its updating cycle.

*Table 5-6: Output specification*

<table>
<thead>
<tr>
<th>Output destination</th>
<th>Register M500-M527</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output contents</td>
<td>Force command value</td>
</tr>
<tr>
<td></td>
<td>Fx,Fy,Fz[0.1N]</td>
</tr>
<tr>
<td></td>
<td>Rx,Ry,Rz[0.01Nm]</td>
</tr>
<tr>
<td>Force FB value</td>
<td>Fx,Fy,Fz, Resultant force (translational)[0.1N]</td>
</tr>
<tr>
<td></td>
<td>Rx,Ry,Rz, Resultant force (rotational)[0.01Nm]</td>
</tr>
<tr>
<td>Content output value update cycle</td>
<td>20msec</td>
</tr>
<tr>
<td>Output bit</td>
<td>16bit</td>
</tr>
</tbody>
</table>

5.3.2 Registers allocation

Registers allocation shown in table 5-7 “Registers as Destination of Allocation”.

*Table 5-7: Registers as Destination of Allocation*

<table>
<thead>
<tr>
<th>M509</th>
<th>M508</th>
<th>M507</th>
<th>M506</th>
<th>M505</th>
<th>M504</th>
<th>M503</th>
<th>M502</th>
<th>M501</th>
<th>M500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force Command (R2) Mx</td>
<td>Force Command (R2) Fz</td>
<td>Force Command (R2) Fy</td>
<td>Force Command (R2) Fx</td>
<td>Force Command (R1) Mz</td>
<td>Force Command (R1) My</td>
<td>Force Command (R1) Mx</td>
<td>Force Command (R1) Fz</td>
<td>Force Command (R1) Fy</td>
<td>Force Command (R1) Fx</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>M519</th>
<th>M518</th>
<th>M517</th>
<th>M516</th>
<th>M515</th>
<th>M514</th>
<th>M513</th>
<th>M512</th>
<th>M511</th>
<th>M510</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force FB (R1) Mx</td>
<td>Force FB (R1) Fz</td>
<td>Force FB (R1) Fy</td>
<td>Force FB (R2) Fx</td>
<td>Resultant Force FB (R2) Rotation</td>
<td>Resultant Force FB (R1) Translation</td>
<td>Resultant Force FB (R1) Rotation</td>
<td>Resultant Force FB (R2) Translation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>M527</th>
<th>M526</th>
<th>M525</th>
<th>M524</th>
<th>M523</th>
<th>M522</th>
<th>M521</th>
<th>M520</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force FB (R2) Mz</td>
<td>Force FB (R2) My</td>
<td>Force FB (R2) Mx</td>
<td>Force FB (R2) Fz</td>
<td>Force FB (R2) Fy</td>
<td>Force FB (R1) Mz</td>
<td>Force FB (R1) My</td>
<td></td>
</tr>
</tbody>
</table>
5.3.3 Setting Method

Output function to the registers and coordinate system of force information can be chosen by allocating information to the pseudo input which are shown in the following table.

**Table 5-8: Pseudo Input allocation**

<table>
<thead>
<tr>
<th>Pseudo Input Signal</th>
<th>Contents</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>82170</td>
<td>Reg Output Valid</td>
<td>OFF: With function</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ON: Without function</td>
</tr>
<tr>
<td>82171</td>
<td>Reserved</td>
<td></td>
</tr>
<tr>
<td>82172</td>
<td>Reserved</td>
<td></td>
</tr>
<tr>
<td>82173</td>
<td>Force Coord Sys</td>
<td>OFF: Robot Coordinate System</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ON: Tool Coordinate System</td>
</tr>
<tr>
<td>82174</td>
<td>Force FB Valid</td>
<td>OFF: No output</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ON: No output</td>
</tr>
<tr>
<td>82175</td>
<td>Force CMD Valid</td>
<td>OFF: No output</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ON: No output</td>
</tr>
<tr>
<td>82176</td>
<td>Reserved</td>
<td></td>
</tr>
<tr>
<td>82177</td>
<td>Reserved</td>
<td></td>
</tr>
</tbody>
</table>

- When #82174 is off, register value M500 to M527 is not Output.
- When #82174 is off and #82170 is on, register value M512 to M527 is not Output.
- When #82175 is off and #82170 is on, register value M500 to M511 is not Output.

*Fig. 5-3: Pseudo Input Signal panel*
5.3.4 Output Trigger

Output force data for registers is start / end with ON / OFF of the following general input.

- IN1017(#01280)ON: started output registers
- IN1017(#01280)OFF: ended output registers

During register output is general output on.
- OUT969(#11220)ON: Output registers

5.3.5 Output Format

Relationship between register output and force information shown in .
Data output is represented by 16 bit data.

Fig. 5-4: Register Output and Force Information
## 6 Troubleshooting

### 6.1 Alarm List

Table 6-1: Alarm List (Sheet 1 of 3)

<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>8008</td>
<td>ALM FSE-TOOL OPEN FCONCND</td>
<td>The force condition file could not be read.</td>
<td>Software (Setting error)</td>
<td>(1) Check the followings and then turn ON the power again.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Connection status of the communication cable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Force sensor type being connected</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(2) If this alarm occurs again, save CMOS.BIN in maintenance mode and tell the</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>situation of the alarm occurrence (such as the operation procedures) to your</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>YASKAWA representative.</td>
</tr>
<tr>
<td>8009</td>
<td>ALM ARG ERR</td>
<td>The parameter for force sensor basic command (macro command) was executed in a status out of setting range.</td>
<td>Software (Setting error)</td>
<td>Confirm that the parameter for the force sensor basic command is set in the setting range.</td>
</tr>
<tr>
<td>8011</td>
<td>FCON ROBOT ERR</td>
<td>The force condition file and the control group in the execution JOB are different.</td>
<td>Software (Setting error)</td>
<td>Set so that the setting for the force condition file and the control group in the execution JOB match.</td>
</tr>
<tr>
<td>8012</td>
<td>IMP ON ERR</td>
<td>FREF or FDET was executed in a status where IMPON was not executed.</td>
<td>Software (Setting error)</td>
<td>Before FREF or FDET is executed, execute IMPON.</td>
</tr>
<tr>
<td>8015</td>
<td>ALM IF MODE</td>
<td>In IF panel, the MotoFit function command was executed in the PC operation mode status.</td>
<td>Software (Setting error)</td>
<td>When executing the MotoFit function command, set to the PP operation enable mode.</td>
</tr>
<tr>
<td>8017</td>
<td>ALM UNMATCH COMMAND</td>
<td>Executing SKILLSND</td>
<td>Software (Setting error)</td>
<td>Execute MotoFit or force sensor basic command.</td>
</tr>
<tr>
<td>8018</td>
<td>ALM TOOLNO ERR (Tool number error)</td>
<td>On the IF panel, tool numbers are set outside the setting range of the DX200/FS100.</td>
<td>Software (Setting error)</td>
<td>Tool numbers on the IF panel must be set within the setting range of the DX200/FS100.</td>
</tr>
<tr>
<td>8022</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>
</tbody>
</table>
### Table 6-1: Alarm List (Sheet 2 of 3)

<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>8023</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 I/F Panel.</td>
</tr>
<tr>
<td>8024</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>
<tr>
<td>8027</td>
<td>ALM EGT JOB SIZE</td>
<td></td>
<td></td>
<td>The job size sent to PC is outside the allowable range.</td>
</tr>
<tr>
<td>8028</td>
<td>ALM_FSE-TOOL_PARAM (FSE-Tool parameter error)</td>
<td>Sub-code: 8</td>
<td>Software (Setting error)</td>
<td>Set the tool number within the setting range of the DX200/FS100 in the “Setting Condition File” of FSE-Tool.</td>
</tr>
</tbody>
</table>
### Table 6-1: Alarm List (Sheet 3 of 3)

<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>8029</td>
<td>ALM_FTEACH (Fitting teaching command error)</td>
<td>Sub-code: 0</td>
<td>Software (Setting error)</td>
<td>Operation order is not correct. Execute FTON command first.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sub-code: 1</td>
<td></td>
<td>A job specified by FTON command is not correct. Check the specified job.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sub-code: 2</td>
<td></td>
<td>FTON command argument is not correct. Check the description.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sub-code: 3</td>
<td></td>
<td>FTEACH command argument is not correct. Check the set value.</td>
</tr>
<tr>
<td>8031</td>
<td>ALM_RESCALE_ERR (RESCALE command execution error)</td>
<td>RESCALE command is executed while force is controlled.</td>
<td>Software (Setting error)</td>
<td>Confirm that the force is not being controlled when RESCALE command is executed by a job.</td>
</tr>
<tr>
<td>8800</td>
<td>ALM_INST_EXEC_PLURAL_GP (Control group 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. The job which executes a FIT command must be one control group of R1/R2.</td>
</tr>
</tbody>
</table>
6 Troubleshooting
6.2 Disabling / Enabling the Force Sensor

6.2 Disabling / Enabling the Force Sensor

Alarm 0831 When retracting the robot while "force sensor communication state error" occurs, or when operating the robot with the force sensor not connected, follow the chapter 6.2.1 "Disabling the Force Sensor" and disable the force sensor.

To re-enable the force sensor, activate the force sensor and set the parameters according to chapter 6.2.2 "Enabling the Force Sensor".

6.2.1 Disabling the Force Sensor

6.2.1.1 FS100

1. Start up the FS100 in the maintenance mode, and set the mode to the management mode. Select (SYSTEM), (SETUP). Move the cursor to "IO MODULE", and press [SELECT].

2. On the IO MODULE window, move the cursor to "DETAIL" of 217IF-01R, and press [ENTER].
6 Troubleshooting
6.2 Disabling / Enabling the Force Sensor

3. On the SENSOR FUNCTION ALLOCATION window, move the cursor to “PORT ALLOCATION” and press [SELECT].

4. On the PORT ALLOCATION window, move the cursor to CH# and press [SELECT].

Note: When two force sensors are used for the single-arm manipulators which are controlled for coordinated operation, perform the same procedures for R2.
5. On the PORT ALLOCATION window, select “NOT USED” in CH#1 and press [ENTER].

Note: When two force sensors are used for the single-arm manipulators which are controlled for coordinated operation, perform the same procedures for R2.

6. When the SENSOR FUNCTION ALLOCATION window is shown again, press [ENTER].
6 Troubleshooting
6.2 Disabling / Enabling the Force Sensor

7. When the following window is shown, press [ENTER].

8. When the confirmation dialog shows up, select {YES}.

9. The disabling procedures are completed. Restart the FS100.
6.2 Disabling / Enabling the Force Sensor

6.2.1.2 DX200

1. Start up the DX200 in the maintenance mode, and set the mode to management mode. Select in the following order: {SYSTEM}, {SETUP}, {OPTION BOARD}. Move the cursor to “Interface466102” to open the Interface466102 setting window.

2. On the Interface466102 setting window, move the cursor to “DETAIL”, and press [ENTER] to open the ROBOT SENSOR OPTION setting window.
6 Troubleshooting
6.2 Disabling / Enabling the Force Sensor

3. Modify the setting of “FORCE SENSOR” for R1 from “O” (valid) to “-” (invalid).

4. After pressing [ENTER], the confirmation dialog shows up. Select {YES} and press [ENTER].
5. The message “Select 'Machine Safety Board FLASH Reset’" is shown in the human interface display area. Set the mode to the safety mode and select in the following order: {FILE}, {INITIALIZE}, 'Machine Safety Board FLASH Reset'.

6. After pressing [ENTER], the confirmation dialog shows up. Select {YES} and press [ENTER].

7. The disabling procedures are completed. Restart the DX200.
6.2 Disabling / Enabling the Force Sensor

6.2.2 Enabling the Force Sensor

6.2.2.1 FS100

1. Start up the FS100 in the maintenance mode, and set the mode to the management mode.
   Select in the following order: {SYSTEM}, {SET UP}, “IO MODULE”.

2. On the IO MODULE window, move the cursor to “DETAIL” of 217IF-01R, and press [SELECT].
6 Troubleshooting
6.2 Disabling / Enabling the Force Sensor

3. On the 217IF-01R window, make sure that “USED” is shown in the line of “217IF-01R” and press [ENTER].

4. When the following window is shown, press [ENTER].
6 Troubleshooting
6.2 Disabling / Enabling the Force Sensor

5. On the SENSOR FUNCTION ALLOCATION window, move the cursor to “PORT ALLOCATION” and press [SELECT].

6. On the PORT ALLOCATION window, move the cursor to CH#1 and press [SELECT].

Note: When two force sensors are used for the single-arm manipulators which are controlled for coordinated operation, the force sensor for R2 is also mounted in the same procedures.
6 Troubleshooting

6.2 Disabling / Enabling the Force Sensor

7. On the PORT ALLOCATION window, select “1” in CH#1 of PORT#1 and press [ENTER].

Note: When two force sensors are used for the single-arm manipulators which are controlled for coordinated operation, the force sensor for R2 is also mounted in the same procedures. In that case, select “2” in CH#2 of PORT#2.

8. When the SENSOR FUNCTION ALLOCATION window is shown, press [ENTER].
6 Troubleshooting
6.2 Disabling / Enabling the Force Sensor

9. When the following window is shown, press [ENTER].

And when the following window is shown, press [ENTER] again.

10. When the confirmation dialog is shown, select {YES}.

11. The enabling procedure is completed.
    Turn off the FS100 and move on to the next chapter.
6.2.2.2 DX200

1. Start up the DX200 in the maintenance mode, and set the mode to management mode. Select in the following order: {SYSTEM},{SETUP},{OPTION BOARD}. Move the cursor to “Interface466102” to open the Interface466102 setting window.

2. On the Interface466102 setting window, after confirming “USED” is shown, move the cursor to “DETAIL” and press [ENTER] to open the ROBOT SENSOR OPTION setting window.
6 Troubleshooting
6.2 Disabling / Enabling the Force Sensor

3. Modify the setting of “FORCE SENSOR” for R1 from “-”(invalid) to “O”(valid).

4. After pressing [ENTER], the confirmation dialog is shown. Select {YES} and press [ENTER].
5. When the message “Select ‘Machine Safety Board FLASH Reset’” is shown in the human interface display area, set the mode to the safety mode and select in the following order: {FILE}, {INITIALIZE}, ‘Machine Safety Board FLASH Reset’.

6. After pressing [ENTER], the confirmation dialog is shown. Select {YES} and press [ENTER].

7. The enabling procedure for the port is completed. Perform the setting by referring to “DX200 MotoFit function Startup Instructions chapter 4 Parameter Setting of MotoFit Function” in the distributed CD included with DX200.
6.3 Replacement and Removal of Force Sensor

6.3.1 Replacement of Force Sensor

Replacement procedure for the force sensor is described as follows. The replacement and mounting must be performed carefully since the force sensor is a precision equipment.

1. Move the robot to face up the flange side for easy removal of the force sensor.
2. Turn OFF the DX200/FS100.
3. Remove the tool installed to the manipulator’s tip.
4. Remove the connector of the force sensor cable.
5. Loosen the bolt which is fixing the force sensor, and remove the force sensor.

![Fig. 6-1: Force Sensor Fixing Bolts](image)

6. Mount the force sensor for replacement. Mount the force sensor in the accordance with the assembly drawing in Dimension Diagram folder in the distributed CD-ROM.

7. By following the procedures of this manual chapter 2.3 “Operation Check”, perform the operation check.

**NOTE**

The mounting direction of the force sensor is different depending on a model of the manipulator. Before the operation check, make sure the sensor is mounted according to the assembly drawing. If the mounting direction is different, the actual operation may be different from the taught operation.
6.3.2 Removal of Force Sensor

The force sensor needs to be removed in case of the following reasons.

- To remove the force sensor since the MotoFit function is not necessary.
- To operate the manipulator temporarily without the force sensor.

The following is the removal procedure.

1. Disable the force sensor communication board port by following this manual chapter 6.2.1 “Disabling the Force Sensor”.

2. Remove the force sensor by following the procedures from No.1 to No.5 in chapter 6.3.1 “Replacement of Force Sensor”.

NOTE
Once the force sensor communication board port is disabled, MotoFit cannot be used. To enable the port again, refer to this manual chapter 6.2.2 “Enabling the Force Sensor”.
6.4 Replacement of Force Sensor Cable

If a cable disconnection etc. occurs, the cable needs to be replaced. Replace the cable according to the following steps.

### 6.4.1 FS100

1. Turn OFF the FS100.
2. Remove the connector of the force sensor cable from the main unit of the sensor.
3. Remove the assembled part.
4. Remove the cable connecting part according to FS100 INSTRUCTIONS Support documentation (MOTOFIT Power-Supply BOX) (HW1481633).
5. Connect a new cable according to FS100 INSTRUCTIONS Support documentation (MOTOFIT Power-Supply BOX) (HW1481633).
6. Fix the assembly part of the cable.
7. Connect the connector of the force sensor cable to the main unit of the sensor.

### 6.4.2 DX200

1. Turn OFF the DX200.
2. Remove the connector of the force sensor cable from the main unit of the sensor.
3. Remove the assembled part.
4. Remove the connector of the force sensor cable from the back side of the DX200.

*Fig. 6-2: Back Side of DX200*

5. Connect the connector of a new force sensor cable to the back side of the DX200.
6. Fix the assembly part of the cable.
7. Connect the connector of the force sensor cable to the main unit of the sensor.
6.5 Replacement and Removal of Force Sensor Board

The procedures for replacement and removal of force sensor board are described as follows. The force sensor board is a precision equipment so that it must be handled carefully.

6.5.1 FS100

6.5.1.1 Replacement of Board

The communication board is fixed on the board rack of the FS100 CPU unit (JEPMC-BUB3008R-E) (refer to FS100 INSTRUCTIONS chapter 13 Description of Units and Circuit Boards). Turn OFF the FS100, and then replace the communication board (JAPMCCM2319R-E) (refer to fig. 6-3 “Replacing the Board”).

Fig. 6-3: Replacing the Board
6 Troubleshooting
6.5 Replacement and Removal of Force Sensor Board

6.5.2 Removal of Board

If the force sensor board needs to be removed since the MotoFit function becomes unnecessary, disable the board in accordance with the following procedures before removal.

NOTE
If the force sensor board is disabled and removed as the following procedures, the setting parameters of the MotoFit function are deleted from the FS100. To use the MotoFit function again, contact YASKAWA representative.

1. The communication board is fixed on the board rack of the FS100 CPU unit (JEPMC-BUB3008R-E) (refer to FS100 INSTRUCTIONS chapter 13 Description of Units and Circuit Boards). Turn OFF the FS100 and the breaker of the force sensor power supply box on the side of the FS100 (following figure), and then removal the communication board (JAPMCCM2319R-E) (refer to fig. 6-3 “Replacing the Board”)

Fig. 6-4: Breaker.

2. Start up the FS100 in the maintenance mode, and set the mode to the management mode. Select {SYSTEM},{SETUP}. Select “IO MODULE” in the setting window.
3. Make sure “217IF-01R” is not shown on the IO MODULE window, and press [ENTER].

![IO Module Window]

4. When the following window is shown, press [ENTER].

![External IO Allocation Window]
6 Troubleshooting
6.5 Replacement and Removal of Force Sensor Board

When the following window is shown, press [ENTER].

5. When the confirmation dialog shows up, select (YES).

6. The disabling procedure is completed. Restart the FS100.
6.5 Replacement and Removal of Force Sensor Board

6.5.2 DX200

6.5.2.1 Replacement of Board

The communication board is fixed on the board rack of the DX200 CPU unit (JZNC-YRK21-1E) (refer to DX200 INSTRUCTIONS chapter 14 Description of Units and Circuit Boards). Turn OFF the DX200, and then replace the communication board (PCI-466102P011).

6.5.2.2 Removal of Board

If the force sensor board needs to be removed since the MotoFit function becomes unnecessary, disable the board in accordance with the following procedures before removal.

1. Start up the DX200 in the maintenance mode, and set the mode to management mode. Select in the following order: {SYSTEM},{SETUP},{OPTION BOARD}. Make sure “Interface466102” is not shown in the setting window, and press [ENTER].

2. When the confirmation dialog shows up, select (YES).
4. The message “Select ‘Machine Safety Board FLASH Reset’” is shown in the human interface display area. Set the mode to the safety mode and select in the following order: {FILE}, {INITIALIZE}, 'Machine Safety Board FLASH Reset'.

5. After [ENTER] is pressed, the confirmation dialog shows up. Select {YES} and press [ENTER].

6. The disabling procedure is completed. Restart the DX200.

6.6 Replacement of MotoFit Power Supply Box (only for the FS100)

Turn OFF the FS100, replace the power supply box according to FS100 INSTRUCTIONS Support documentation (MOTOFIT Power-Supply BOX) (HW1481633).
7 Remarks

7.1 Maximum load of the force sensor

The load applied on the force sensor must not exceed the rated load. If a load exceeding the rated load is applied during force control, the Alarm No.4880 “Excess force detection error” occurs and the manipulator stops its operation. Any failure of the sensor caused by overloading cannot be covered by the warranty of YASKAWA. If a load exceeds the maximum static load of the force sensor, the sensor may be damaged.

For the axis definition of the force sensor, refer to fig. 7-1 “Axis Definition for the Force Sensor Detection”. For the rated load and the maximum static load of the force sensor, refer to table 7-1 “Mass, Rated Load and Maximum Static Load of the Force Sensor”.

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

Fig. 7-1: Axis Definition for the Force Sensor Detection

<table>
<thead>
<tr>
<th>Thickness L [mm]</th>
<th>Detection center Lc [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Six-axis sensor (rated 200N)</td>
<td>32.5</td>
</tr>
<tr>
<td>Six-axis sensor (rated 1000N)</td>
<td>40</td>
</tr>
</tbody>
</table>
7.2 Setting of Tool information

The tool information of the robot must be properly set according to the tool to be used. If the information is not properly set, the actual operation may be different from the taught operation.

7.3 Setting of Force Condition File

When the force control by MotoFit function is performed, the following items of the force condition file must be set. Robot, Coordinate system, Tool No., Insertion direction, Valid axes. If they are not set, the manipulator may not perform the operation which is taught.

7.4 Moving Direction of MotoFit Function

The rated load of the moment is small compared to the rated load of the force. During an operation, the manipulator must keep a posture in which the flange of the manipulator’s tip faces to the ground. If the operation is performed with any posture other than above, the rated load of the moment may be exceeded depending on the weight of workpiece or tool.

7.5 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.

7.6 Usage of “TOUCH”, “FIT”, and “INSERT”

Use the TOUCH, FIT, and INSERT commands in the following operation step. 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” occurs if a FIT or INSERT command is executed when a TOUCH command has not been executed yet.

Table 7-1: Mass, Rated Load and Maximum Static Load of the Force Sensor

<table>
<thead>
<tr>
<th></th>
<th>Six-axis sensor (rated 200N)</th>
<th>Six-axis sensor (rated 1000N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>360 g</td>
<td>500 g</td>
</tr>
<tr>
<td>Rated Load (Force) (Fx, Fy, Fz)</td>
<td>200 N</td>
<td>1000 N</td>
</tr>
<tr>
<td>Rated Load (Moment) (Mx, My, Mz)</td>
<td>4 N·m</td>
<td>30 N·m</td>
</tr>
<tr>
<td>Maximum Static Load (Force) (Fx, Fy, Fz)</td>
<td>1000 N</td>
<td>5000 N</td>
</tr>
<tr>
<td>Maximum Static Load (Moment) (Mx, My, Mz)</td>
<td>6 N·m</td>
<td>50 N·m</td>
</tr>
</tbody>
</table>
7.7 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.

7.8 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.

7.9 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.

7.10 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
- Occurs an alarm

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

7.11 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.
7.12 Restrictions of Usage Environment

This function cannot be used in the environment in which the influence of the electric noise is strong such as the welding line or etc. Due to the influence of electric noise, the sensor may not properly perform.

7.13 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.

Fig. 7-2: Workpiece Slips

7.14 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.

7.15 Payload of the Robot

Include the mass of force sensor to the payload. Refer to table 7-1 “Mass, Rated Load and Maximum Static Load of the Force Sensor” for the mass of force sensor.

7.16 Force Sensor

For this function, the force sensor other than YASKAWA must not be used. When mounting the force sensor, the spacers other than YASKAWA must not be used. If the spacers other than YASKAWA are used, contact YASKAWA representative.
8 Supplemental Information

8.1 Specifications

8.1.1 Specifications of MotoFit

<table>
<thead>
<tr>
<th>Items</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functions to move</td>
<td>Precision fitting, Following external force, Force detection</td>
</tr>
<tr>
<td>Teaching tool</td>
<td>The Inner Force Sense Function Engineering Support Tool</td>
</tr>
<tr>
<td>6-axis force sensor</td>
<td>Dedicated Sensor (delivered with DX200/FS100)</td>
</tr>
<tr>
<td></td>
<td>(Rated 200N and 1000N)</td>
</tr>
<tr>
<td>Fitting conditions</td>
<td></td>
</tr>
<tr>
<td>Shape of Workpiece</td>
<td>Cylinder</td>
</tr>
<tr>
<td>Fitting gap</td>
<td>h7/H7 in JIS tolerance, with gap more than 10μm</td>
</tr>
<tr>
<td>Chamfer</td>
<td>C0.1 or more in JIS tolerance</td>
</tr>
<tr>
<td>Initial Position Error Tolerance</td>
<td>±1mm</td>
</tr>
<tr>
<td>Initial Angle Error Tolerance</td>
<td>±1.0°</td>
</tr>
</tbody>
</table>

8.1.2 Specifications of Force Sensor

<table>
<thead>
<tr>
<th>Items</th>
<th>6-axis force sensor (rated 200N)</th>
<th>6-axis force sensor (rated 1000N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated load Force (Fx, Fy, Fz)</td>
<td>200N</td>
<td>1000N</td>
</tr>
<tr>
<td>Rated load Moment (Mx, My, Mz)</td>
<td>4Nm</td>
<td>30Nm</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>24V DC</td>
<td></td>
</tr>
<tr>
<td>Sampling Frequency</td>
<td>2kHz</td>
<td></td>
</tr>
<tr>
<td>Dustproof and Waterproof</td>
<td>IP65</td>
<td></td>
</tr>
<tr>
<td>Inductive noise immunity</td>
<td>EN61000-6-4, EN61000-6-2</td>
<td></td>
</tr>
<tr>
<td>Maximum shock</td>
<td>50G (3 times, with no weight)</td>
<td></td>
</tr>
<tr>
<td>Maximum vibration</td>
<td>5G(10-2kHz, X,Y,Z each direction 25hours, with no weight)</td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td>φ 80(mm)×H32.5mm</td>
<td>φ 90(mm)×H40mm</td>
</tr>
<tr>
<td>Weight</td>
<td>360g</td>
<td>580g</td>
</tr>
</tbody>
</table>

8.2 Extended applications by using MotoPlus

For the MotoPlus function, which is the new language for MOTOMAN, the API for the force control is prepared. By utilizing this function, various applications can be developed by user. For details of MotoPlus, contact nearby YASKAWA representative.

**NOTE** MotoFit function and the MotoPlus application which is developed by user cannot be used simultaneously.
DX200/FS100 OPTIONS
INSTRUCTIONS
for MotoFit

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YASKAWA

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