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

**MOTOMAN INSTRUCTIONS**
- MOTOMAN-□□□ INSTRUCTIONS
- FS100 INSTRUCTIONS
- FS100 OPERATOR’S MANUAL
- FS100 MAINTENANCE MANUAL

Part Number: 161368-1CD
Revision: 0
MANDATORY

- This manual explains the servofloat function for coordinated operation of two robots of the FS100 system. Read this manual carefully and be sure to understand its contents before handling the FS100.
- General items related to safety are listed in Chapter 1: Safety of the FS100 Instructions. To ensure correct and safe operation, carefully read the 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 FS100.

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

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 “CAUTION” and “WARNING”.
WARNING

• Before operating the manipulator, check that servo power is turned off when the emergency stop button on the programing pendant is pressed.
  When the servo power is turned off, the SERVO ON LED on the programing pendant is turned off.

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

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 prepare 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.

Injury may result from unintentional or unexpected manipulator motion.

Fig. : Release of EM

• Observe the following precautions when performing teaching operations within the P-point maximum envelope of the manipulator:
  – View the manipulator from the front whenever possible.
  – Always follow the predetermined operating procedure.
  – Ensure that you have a safe place to retreat in case of emergency.

Improper or unintended manipulator operation may result in injury.

The emergency stop button is located on the programing pendant.
**Definition of Terms Used Often in This Manual**

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></td>
</tr>
<tr>
<td>Character Keys</td>
<td>The keys which have characters printed on them are denoted with [ ]. ex. [ENTER]</td>
</tr>
</tbody>
</table>
| Symbol Keys                | The keys which have a symbol printed on them are not denoted with [ ] but depicted with a small picture. ex. PAGE key
|                            | The Cursor is an exception, and a picture is not shown.                            |
| Axis Keys                  | “Axis Keys” and “Numeric Keys” are generic names for the keys for axis operation and number input. |
| Numeric Keys               |                                                                                   |
| Keys pressed simultaneously | When two keys are to be pressed simultaneously, the keys are shown with a “+” sign between them, ex. SHIFTkey + COORD key |
| Mode Key                   | Three kinds of modes that can be selected by the mode key are denoted as follows: REMOTE, PLAY, or TEACH |
| Button                     | Three buttons on the upper side of the programming pendant are denoted as follows: HOLD button START button EMERGENCY STOP button |
| Displays                   | The menu displayed in the programming pendant is denoted with { }. ex. {JOB}        |
| PC Keyboard                | The name of the key is denoted ex. Ctrl key on the keyboard                        |

**Description of the Operation Procedure**

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

**Registered Trademark**

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FS100

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   6.4  A Setting Example for the Link Servofloat Condition File ..................................... 6-6
1 Servofloat Function

The servofloat function of the FS100 consists of the link servofloat function and the linear servofloat function. The link servofloat function controls the torque independently for each axis; and the linear servofloat function controls the torque on the Cartesian coordinates. Select these two functions by setting the servofloat instructions accordingly.

1.1 Link Servofloat Function

The link servofloat function works in combination with the position control and the torque control, whereas an ordinary control is a position control that generates torque to keep the taught position regardless of the applied external force. “Torque control” keeps the taught position only by using the torque against the gravitational and frictional forces. Therefore, a manipulator moved by an external force will not return to its original position.

With the servofloat function, external force moves the manipulator since the torque control has priority over the position control.

For example, when removing a workpiece from the die-casting machine, a large external force is applied to the manipulator by the extruding cylinder when a workpiece is grasped and pulled out. The servofloat function is used to protect the manipulator from excessive external force, and the manipulator moves according to the force applied from the die-casting machine.

Note that the manipulator does not move exactly to the taught position or along the taught path, because complete position control is not performed during execution of the servofloat function.
1.2 Linear Servofloat Function

When a manipulator pushes a workpiece or visa-versa, a movement to one predetermined direction may be desirable. With the link servofloat function, a servofloat motion in one direction is not possible since torque control is performed independently for each axis.

This function can specify the control of force in one direction within a space.*1

When unloading a die-casting machine, this function is useful for considerably long ejection distances or when polishing or grinding.

*1 When external force is applied, the R, B, and T-axes move the same as in the link servo-float function. Only the end of the U-axis moves in a linear motion.

1.3 Using the Link Servofloat Function and the Linear Servofloat Function

Use the link servofloat function when high-frequency noise, motor vibration, or unsteady manipulator motion occur depending on the manipulator posture, speed, and movement direction.

**Tool load information setting**

- The servofloat function compensates for gravity in real-time in order to prevent the arms from dropping due to gravity even when the generated torque is limited. For this purpose, the tool load information used for gravity compensation must be set correctly. Otherwise, the servofloat function cannot be performed properly and the arms may drop down or rise up.

- For the tool load information, refer to Section “8.4.3 Setting Tool Load Information” in the FS100 INSTRUCTIONS (manual number: RE-CTO-A218) to correctly set the tool load information.
Enable the servofloat function with the servofloat function start instruction FLOATON. It remains enabled until one of the following conditions is established.

- Performing the a servofloat function end instruction FLOATOF
- Performing the FWD/BWD key operation, jogging, or a job startup after the cursor is moved
- Performing the FWD/BWD key operation, jogging, or a job startup after a job call, job selection, or job editing
- Turning the servo ON again after an emergency stop

When the function is enabled, the manipulator generates only the torque that is less that the value set to the servofloat condition file. The manipulator uses the torque to operate and keep the position. If a large external force is applied, the manipulator moves according to this force.
2.1 Moving with the Move Instruction

If an external force prevents manipulator operation, the manipulator does not reach the taught position when the servofloat function is enabled. Even though the manipulator does not actually reach the taught position, the instruction that would be activated at that position are nonetheless enabled, so the move instruction terminated.

Therefore, when the manipulator cannot reach the taught position because of an external force, the manipulator performs the next instruction.

The following figure shows an example where the operation time is 5 seconds from STEP 1 to STEP 2. If the manipulator hits an obstruction 3 seconds after STEP 1 and stops there, it remains stopped at the position for the remaining 2 seconds, and then moves to STEP 3 without moving to STEP 2 when moving with the torque control.
2.2 Moving with the TIMER and WAIT Instructions

When the servofloat function is enabled, torque control can be performed even during the TIMER and WAIT instructions. These instructions end when time is up or when a condition described in page 2-1 is established.

For example, in the following figure, the manipulator reaches STEP 1, and the FLOATON instruction enables the servofloat function. Then the manipulator waits for the input of IN#1 by the WAIT instruction. In this state, if an external force is applied to the manipulator, the manipulator moves to the point P and stops. If the FLOATOF instruction is performed at this point, the servofloat function is disabled and the manipulator moves from point P to STEP 2.

2.3 Operation Check

When the servofloat function is enabled, the soft limit, cube interference, and the S-axis interference are checked at the actual position of the manipulator even though external force moved the manipulator.

2.4 When an Alarm Occurs

If an alarm occurs when the servofloat function is enabled, the servofloat function may remain effective depending on the type of alarm.

To disable the servofloat during an alarm, enter “external emergency stop” or “servo OFF signal” during the “alarm occurrence” signal output. This turns OFF the servo power supply and applies the brakes.

2.5 Display during Servofloat Operation

When the servofloat function is enabled, the message “Servo float activated” appears at the bottom of the programming pendant display, and the specific output #50510 to #50511 “SERVOFLOAT ON R1 to R2” is output.
2.6 Turning Servo ON Again During Servofloat Operation

When the servo power has been turned OFF due to an emergency stop during servofloat operation and turns ON again, press the [SERVO ON READY] on the playback panel until this servo recognizes that the power supply is turned ON. If the button is not pressed for a long enough time, the message “depress servo power ON” appears and the servo power cannot be turned ON.
3 Servofloat Condition Files

There are two kinds of servofloat condition files: the link servofloat condition file specified for the link servofloat function, and the linear servofloat condition file specified for the linear servofloat function.

3.1 Link Servofloat Condition File

3.1.1 Procedures

1. Select {ROBOT} from the main menu.
2. Select {LINK SERVOFLOAT} – The link servofloat window appears.
3. Select an item to be set, and set the value.
   (1) The display enters the number input status.
   (2) Enter a value for “MAX. TORQUE” by pressing the numeric keys.
4. Press [ENTER].

CAUTION

- If the values for the maximum force and maximum torque are set too low, gravity may cause an arm to drop.

The arm drop may cause an accident or damage to the devices.
3.1.2 Link Servofloat Condition Setting

A. FUNC

Enables/Disables the linear servofloat function for each axis.

“●” indicates that the function is enabled; “○” indicates that the function is disabled.

Pressing [SELECT] switches between “●” and “○”.

B. (+) MAX. TORQUE / (-) MAX. TORQUE

Limits the amount of torque generated for keeping control of the position of each axis.

Set the value for each axis using the ratios (%) of the positive and negative sides of the motor to the motor rated torque.

The smaller the value is set, the more easily an axis can be moved by an external force.
3.2 Linear Servofloat Condition File

3.2.1 Procedures

1. Select {ROBOT} from the main menu.
2. Select {LNR. SERVOFLOAT}
   – The linear servofloat window appears.

![Linear Servofloat Window]

3. Select an item to be set, and set the value.
   (1) The display enters the number input status.
   (2) Enter a value for “MAX. TORQUE” by pressing the numeric keys. Then, press [ENTER].

4. Press [ENTER]
3.2.2 Linear Servofloat Condition Setting

**A. COORDINATE**
Sets a coordinate system for the linear servofloat function.
Select the ROBOT coordinates, BASE coordinates, USER coordinates or TOOL coordinates.
The selection dialog box appears by pressing [SELECT]. Select a coordinate system to be set.

**B. FUNC**
Enables/Disables the linear servofloat function for each axis.
“●” indicates that the function is enabled; “○” indicates that the function is disabled.
Pressing [SELECT] switches between “●” and “○”.

**C. (+) MAX. FORCE / (-) MAX. FORCE**
Limits the amount of force generated for keeping control of the position of each axis.
When the linear servofloat is enabled, a force bigger than this set value is not generated.
The smaller the value is set, the more easily a set coordinate axis can be moved by an external force.
However, if the set value is less than the manipulator friction, the manipulator may not move.
3.2 Linear Servofloat Condition File

D. (+) MAX. TORQUE / (-) MAX. TORQUE

Limits the amount of torque generated for keeping control of the position of R-, B-, and T-axes.

Set the value for each axis using the ratios (%) of the positive and negative sides of the motor to the motor rated torque.

The smaller the value is set, the more easily an axis can be moved by an external force.
4 Instructions for the Servofloat Function

4.1 FLOATON Instruction

FLOATON is an instruction to enable and start the link servofloat function or the linear servofloat function.

Additional items for the FLOATON instruction are as follows:

A. FL# ( ) (Setting range: 1 to 8)
   Sets the link servofloat condition file number.

B. LFL# ( ) (Setting range: 1 to 8)
   Sets the linear servofloat condition file number.

4.2 FLOATOF Instruction

FLOATOF is an instruction to disable and end the link servofloat function or the linear servofloat function. The servofloat function can be also disabled by performing servo OFF.

4.3 SPDL Tag

The SPDL tag is a stop confirmation tag with which a motion is completed when the number of speed feedback pulses of all the axes becomes less than a constant value.

Use an SPDL tag to confirm the end of a motion caused by an external force. Add it to the move instruction immediately before the FLOATOF instruction.

If the move instruction is completed with a SPDL tag added, the next instruction will not be performed as long as the manipulator is being moved by an external force.

Only "0" can be set for the SPDL tag.

An example of an SPDL tag added to a move instruction is shown as follows:

MOVJ VJ=50.00 SPDL=0
5 Registration of Instruction

When in the job content display in teach mode, register an instruction with the cursor in the address area.

1. Select {JOB} from the main menu.
2. Select {JOB CONTENT} – The job content window appears.
3. Move the cursor to the address area.

5.1 FLOATON Instruction

1. Move the cursor to the line where “FLOATON” is to be registered.
3. Select “FLOATON” – The “FLOATON” instruction appears in the input buffer line.
4. Change any additional items and numerical values.
   – < To register without change>
     To register the instruction displayed in the input buffer line without
     any changes, go to step 5.
   – < To edit the additional items>
     (1) To add an additional item, with the cursor on the instruction in the
     input buffer line, press [SELECT] to call the detail edit display.
     (2) With the cursor on “UNUSED” for the “SV FLOAT FILE”, press
     [SELECT].
     – The selection dialog box appears with the choices “FL# ( )” or “LFL#
     ( )”. Select one.
     (3) After adding an additional item, press [ENTER].
     – The detail edit display closes, and the job content display reappears.

5. Press [INSERT] and [ENTER]
   – The instruction displayed in the input buffer line is registered.
5.2 FLOATOF Instruction

1. Move the cursor to the line where “FLOATOF” is to be registered.
2. Press [INFORM LIST]
   – The instruction dialog box appears.
3. Select “FLOATOF”
   – The “FLOATOF” instruction appears in the input buffer line.
4. Press [INSERT] and [ENTER]
   – The instruction displayed in the input buffer line is registered.
5.3 Addition of SPDL Tag to a Move Instruction

When in the job content display in teach mode, add an SPDL tag to a move instruction, with the cursor in the instruction area.

1. Select the line of the move instruction where the SPDL tag is to be added.
   - The move instruction appears in the input buffer line.

2. Press [SELECT]
   - The detail edit window appears.

   (1) With the cursor on “UNUSED” for the “POS LEVEL”, press [SELECT].
   - The selection dialog box appears with the choice, “SPDL=”.

   (2) After adding “SPDL=” to the move instruction, press [ENTER].
   - The detail edit window closes, and the job content window reappears.

3. Press [INSERT] and [ENTER]
   - The instruction displayed in the input buffer line is registered.
6 Application Example of the Servofloat Function

When removing a workpiece from a die-casting machine, a large external force is applied to the manipulator during extraction after grasping it. In such a case, the following example is applicable using the servofloat function.

6.1 Movement Example

1. Moves to the waiting point.

2. Moves to the grasping starting point and performs the TIMER instruction, and then starts the servofloat function.

3. When function enabled, the manipulator grasps a "biscuit".
4. After having grasped a workpiece, the “start extraction instruction” signal is output, and the manipulator performs an extracting motion.

5. The “start extraction instruction” signal starts the extraction operation of the die-casting machine.
   – Thereby, the manipulator performs an extracting motion.

6. The die-casting machine outputs the “end extraction instruction” signal when the manipulator reaches the completion position.
   – The manipulator ends the servofloat function.
7. The manipulator returns to its normal motion and performs an extraction motion with the workpiece.

8. Then, it returns to the home position.
6.2 Job Example

<table>
<thead>
<tr>
<th>No.</th>
<th>Explanation</th>
<th>Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(^1)</td>
<td>Moves to the waiting point.</td>
<td>MOVJ VJ=50.0</td>
</tr>
<tr>
<td>2</td>
<td>Moves to the workpiece grasping point.</td>
<td>MOVL V=300.0</td>
</tr>
<tr>
<td></td>
<td>Stops and waits for 0.5 seconds.</td>
<td>TIMER T=0.50</td>
</tr>
<tr>
<td></td>
<td>Starts the linear servofloat function.</td>
<td>FLOATON LFL#(1)</td>
</tr>
<tr>
<td>3</td>
<td>Turns ON the “grasping instruction” signal. (general output No. 10)</td>
<td>DOUT OT#(10)=1</td>
</tr>
<tr>
<td></td>
<td>Waits for the “grasping answer” signal. (general input No. 10)</td>
<td>WAIT IN#(10)=1</td>
</tr>
<tr>
<td>4</td>
<td>Turns ON the “start extraction instruction” signal. (general output No. 11).</td>
<td>DOUT OT#(11)=1</td>
</tr>
<tr>
<td>5</td>
<td>Performs the extraction motion. Ends the motion when the “end extraction instruction” signal (general input No. 11) is input during the motion.</td>
<td>MOVL V=50.0 UNTIL IN#(11)</td>
</tr>
<tr>
<td></td>
<td>Stops and waits for 0.5 seconds.</td>
<td>TIMER T=0.50</td>
</tr>
<tr>
<td>6</td>
<td>Completes the servofloat function.</td>
<td>FLOATOF</td>
</tr>
<tr>
<td>7</td>
<td>Starts the extracting.</td>
<td>MOVL V=300.0</td>
</tr>
<tr>
<td></td>
<td>Returns to the waiting point.</td>
<td>MOVJ VJ=50.0</td>
</tr>
</tbody>
</table>

\(^1\) The numbers represent the procedure numbers in chapter 6.1 “Movement Example” at page 6-1.
6.3 A Setting Example in the Linear Servofloat Condition File

For the example described in chapter 6.1 “Movement Example” at page 6-1.

In the example, the extracting direction corresponds to that of the Y-axis of the robot coordinates.

If the direction does not correspond to the robot coordinates, define the extracting direction with the user coordinates and set “COORDINATE” to “USER#01”.

![Servofloat Function Setting Example](image-url)
6.4 A Setting Example for the Link Servofloat Condition File

For the example described in chapter 6.1 “Movement Example” at page 6-1, specify the link servofloat condition file by specifying LF# as the FLOATON instruction file. In this case, a setting example is as follows.

Since the S-axis moves according to the force applied by the extruding cylinder of the die-casting machine, set the “MAX. TORQUEs” of the S-axis to “0”. Set the “MAX. TORQUEs” of the L- and U-axes to “30” to prevent the arms from dropping or rising up due to the load variation. To orientate the tool posture, set the “MAX. TORQUEs” of the R-, B-, and T-axes to “100”.

Using the above settings as a guide, adjust the ratio of each set value according to the circumstances.
FS100 OPTIONS
INSTRUCTIONS
FOR SERVOFLOAT FUNCTION

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YASKAWA

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