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Hyundai Robot

Hi5SF121101FMEN1

Hi5 Controller Function Manual

ServoFree

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1 Function Overview

1.1. Introduction

The ServoFree has a function by which a robot may move naturally, responding to a external force; therefore there is no need for additional hardware such as a force sensor in using the function because it is run in a software way. Because the robot without the Servofree function (or with the inactivated ServoFree function) is controlled to follow the planed directions, it does not slide by the external force. So the ServoFree function is necessary for a robot tool to slide naturally in line with the ejector's motion of an injection molding machine during the operations such as taking out injection molded products.

One of the axial directions of the coordinate system provided by the controller is a possible direction to slide by the external force. And the robot may slide along any spatial lines with the use of the user's coordinate system. While the robot slides, the tool holds its position which has been set up right before the activation of the ServoFree function.

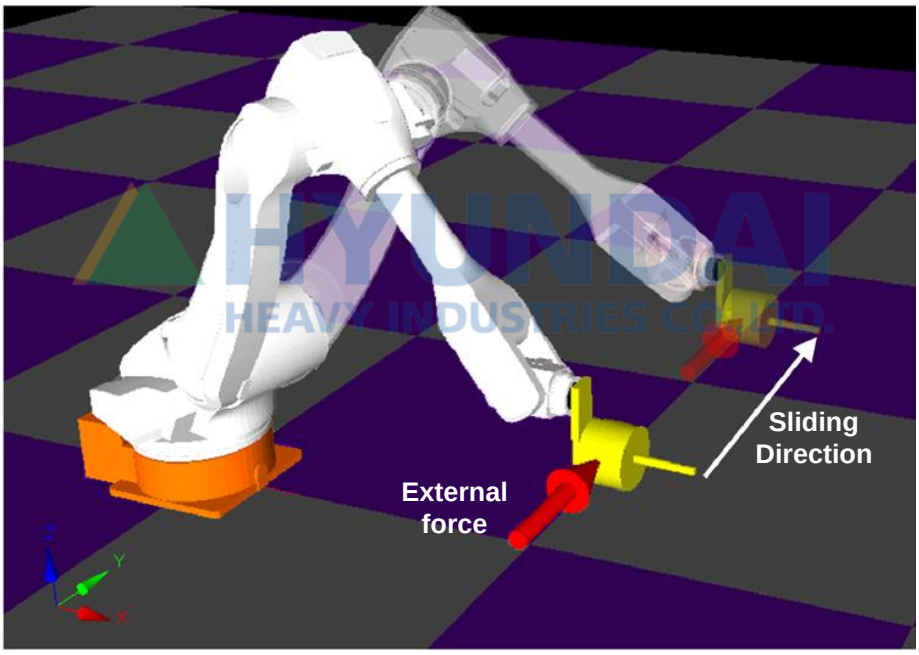

Figure 1.1 Example of ServoFree (When the function is activated in the +Y direction of the robot coordinate system)

1.2. Summary on Functions

- Sliding Direction: One of +X, -X, +Y, -Y, +Z, and -Z directions of the user's coordinate system
- Supported Coordinate System: Base, Robot, Tool and User coordinate systems
- Holding the tool position while it slides.
- Maximum Sliding Distance: 1,000mm
- Maximum Sliding Rate: 300mm/s
- Applicable Robot: 6-axis Serial Link Robot

2 Use Methods

2.1. ServoFree Program Structure

To use the ServoFree function, first, set up the maximum sliding distance and the maximum sliding rate. Next, input a normal coordinate system and a sliding direction. After the ServoFree function has been activated, send the signal to start the job to the device that applies an external force, and wait to receive the signal to terminate the job. Lastly, inactivate the ServoFree function after all the sliding operations have ended.

Division	Description	Examples of Programs
Set up Conditions and Start Functions	Set up the maximum sliding distance and the rate, normal coordinate system, sliding direction, gain, etc. and start the ServoFree function.	LIMIT POS,+Y=500 LIMIT VEL,Y=300 ServoFree ON, CRD=1, ……
Sliding Section	It is the section where the ServoFree function is inactivated, and in practice, the robot tool slides. Direct the command of pushing the robot through the devices such as an injection molding machine that apply external forces and DIO communications, or receive the signals such as endtask.	DO10=1 WAIT DI10
Function ends	Terminate the ServoFree function.	ServoFree OFF

2.2. ServoFree Commands

The commands used for the ServoFree function are the 'LIMIT' used for setting up the maximum sliding distance and maximum sliding rate and the 'ServoFree' used for activating/inactivating the ServoFree function.

2.2.1. LIMIT command

<table>
<tr><td>Description</td><td colspan="3">It is a command to set up the maximum sliding distance and maximum sliding rate before the ServoFree function is activated.</td></tr>
<tr><td>Input Method</td><td colspan="3">『[F6]: Input the command』 → 『[F1]: Motion, I/O』 → 『PREV/NEXT』 → 『PREV/NEXT』 → 『[F7]: LIMIT』</td></tr>
<tr><td>Sentence rule</td><td colspan="3">LIMIT POS,<limit by direction>
LIMIT VEL,<limit by direction></td></tr>
<tr><td rowspan="4">Parameter</td><td rowspan="2">Limited Subject</td><td>POS</td><td>Set up the max sliding distance</td></tr>
<tr><td>VEL</td><td>Set up the max sliding rate</td></tr>
<tr><td rowspan="2">Limit by Direction</td><td>In case of POS</td><td>0~1,000[mm]</td></tr>
<tr><td>In case of VEL</td><td>0~300[mm/s]</td></tr>
<tr><td>Example</td><td>LIMIT POS,+Y=500
LIMIT VEL,Y=300</td><td colspan="2">Set up the max sliding distance by 500[mm] in the +Y direction; the max sliding rate by 300[mm/s] in the Y direction.</td></tr>
<tr><td>Note</td><td colspan="3">▪ Before executing the command of ServoFree ON, make sure to set up the maximum sliding distance and maximum sliding rate in the sliding direction, by using the command of LIMIT.
▪ When a robot slides to the extent of the max sliding distance, it no longer slides even with the external force.
▪ The robot tool does not slide at a speed beyond the max sliding rate even with a large external force.
▪ When the input limit is zero (0), it does not slide,; or when the limit is not input in a certain direction, it does not slide in that direction.</td></tr>
</table>

Note: The maximum sliding distance is the lineal distance between the initial point of sliding at the end of a tool and the endpoint of sliding of the tool that may slide to the maximum extent possible, which is shown in the following figure.

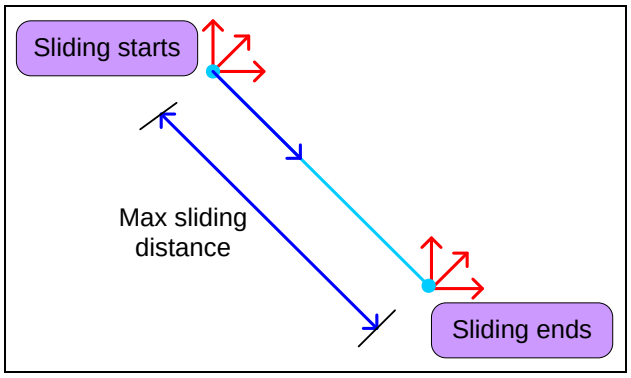

Figure 2.1 Maximum sliding distance

2.2.2. ServoFree command

Description	It is a command to activate (on) or inactivate (off) the ServoFree function.		
Input methods	『[F6]: Input the command』→『[F1]: Motion, I/O』→『PREV/NEXT』→ 『PREV/NEXT』→『[F4]: ServoFree』		
Sentence Rule	LIMIT ON,<Used coordinate system(CRD)>,<sliding direction(DIR)>,<sensitivity gain(GAIN)>,<threshold of external force(F)> LIMIT OFF		
Parameter	Use or not	ON	Activate ServoFree function
		OFF	Inactivate ServoFree function
	Used Coordinate System(CRD)	0: Base, 1: Robot, 2: Tool, 3: U(current user's coordinate system), 4: Un(user's coordinate system n)	
	Sliding Direction(DIR)	Among +X, -X, +Y, -Y, +Z, -Z, choose one	
	Sensitivity Gain(GAIN)	1~100	
	Threshold of External Force(F)	1~100	
Example	ServoFree ON,CRD=1,DIR=+Y,GAIN=50,F=50		
	Activate the Servofree function by setting up the sliding direction in the +Y of the robot coordinate system.		
Note	▪ The value of sensitivity gain is within 1-100. The bigger the value is, the more a robot tool reacts sensitively to the external force. That is, if the external force is the same, the tool whose Gain is 100, slides faster than that whose GAIN is 1. ▪ The higher a threshold of external force (F) is, the larger an external force is needed to move the tool at the same speed. When the robot slides even without external forces, create the large value of F.		

2.3. Methods of Using ServoFree Function

Step 1: Check Whether the ServoFree Function Works

Before tuning a detailed gain of ServoFree, check whether the ServoFree function that a robot has works. Set up the maximum sensitivity (GAIN=100) and minimum disturbance threshold (F=1) so as to make the robot slide even without external forces applied to the robot.

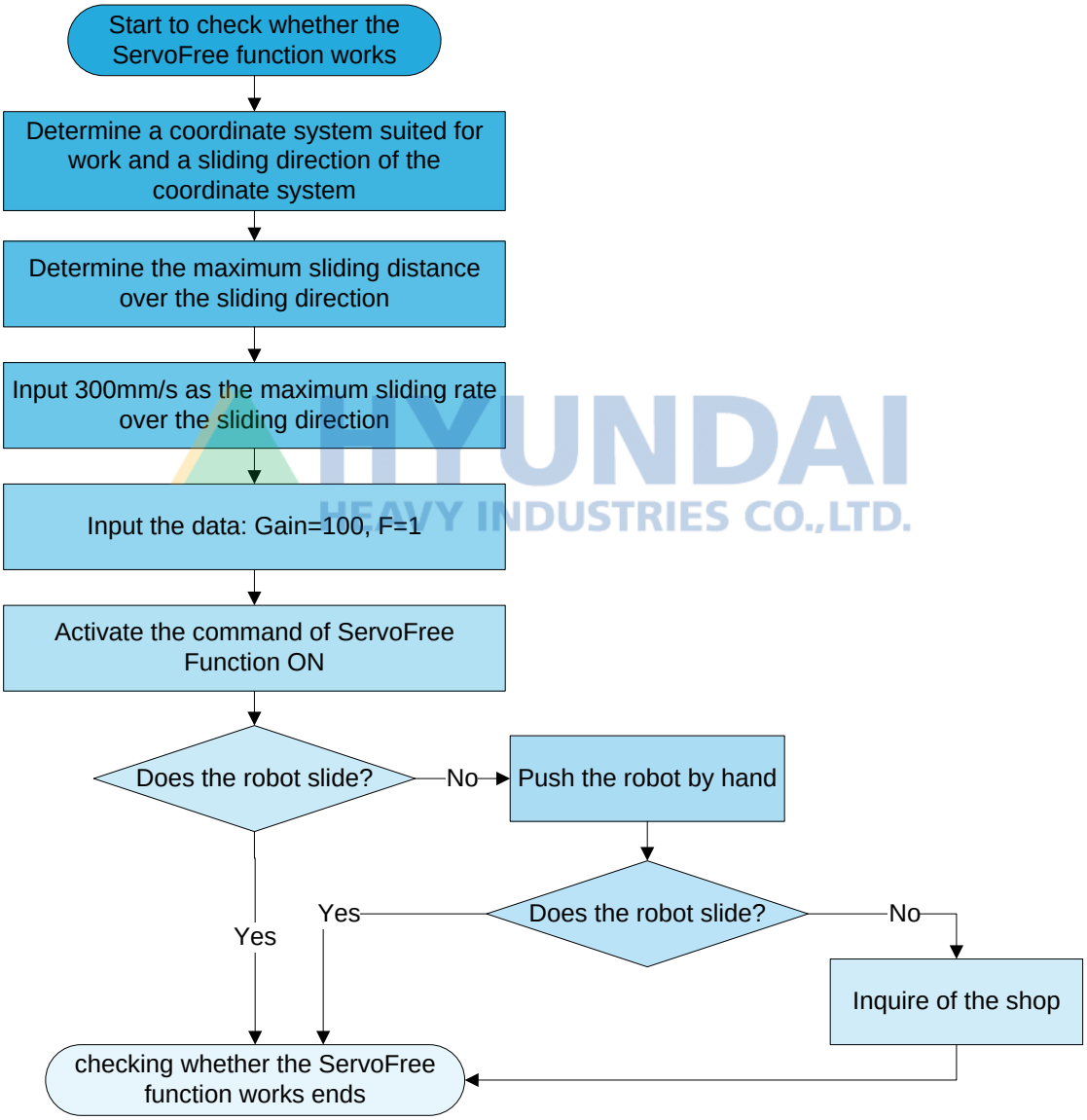

Figure 2.2 Flow chart to check whether the ServoFree function works

```
S1     MOVE P,S=10%,A=1,T=1
       DELAY 2.0
       LIMIT POS,+Y=500
       LIMIT VEL,Y=300
       ServoFree ON,CRD=1,DIR=+Y,GAIN=100,F=1
       DELAY 10
       ServoFree OFF
       END
```

Figure 2.3 Examples of programs for checking whether the ServoFree function works

Step 2: Detailed Gain Tuning according to the work

Tune the detailed gain so as to fit the work after checking that the used robot's ServoFree function has worked. After starting the ServoFree function, gradually increase values of disturbance threshold (F) from one (1) in order to prevent the robot from sliding in a condition where an external force is zero (0).Then, adjust sensitivity gains until the gain suitable for the work is obtained, and regulate maximum sliding rates in accordance with sliding rates.

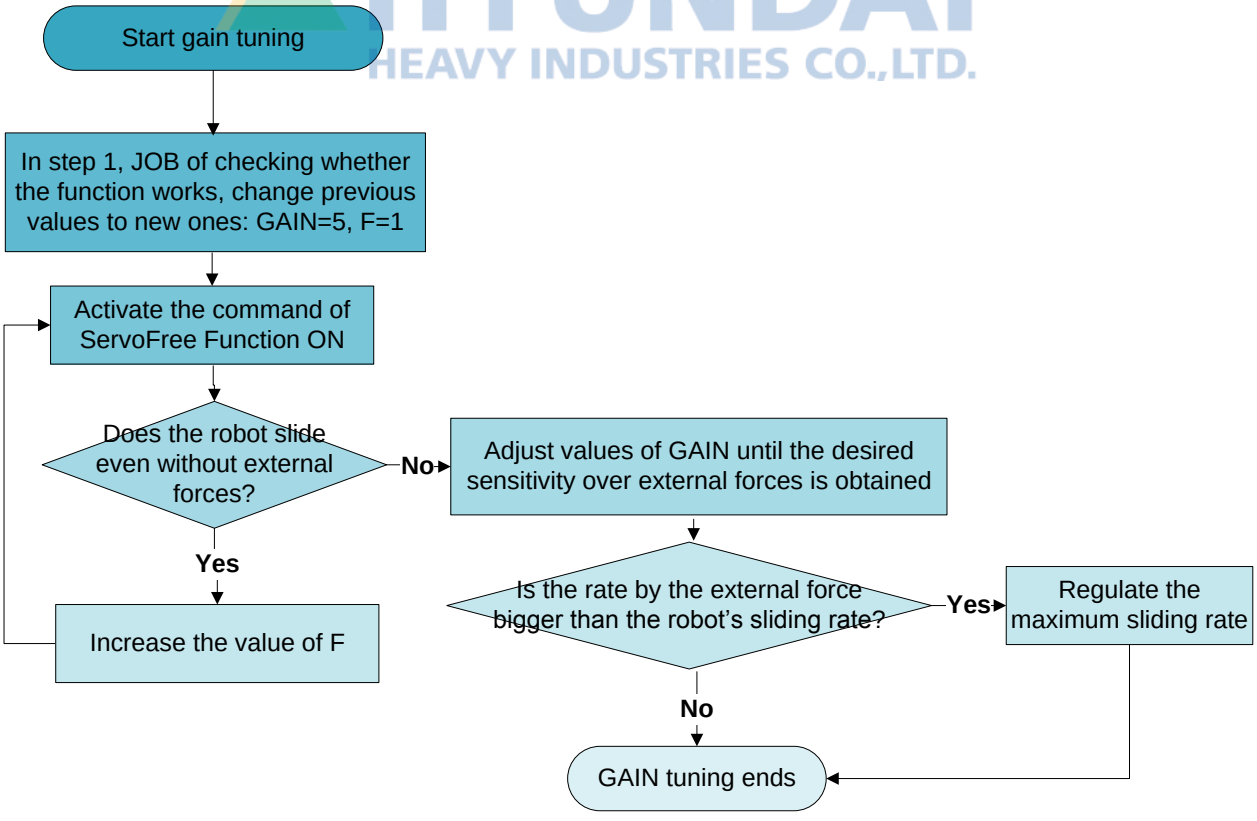

Figure 2.4 Flow chart of ServoFree function gain tuning

3 Other Matters

3.1. Special Note

(1) The most sensitive reaction direction to the external force is the right and left directions (±Y) of the robot's coordinate system. It recommended to install a robot in a way that makes the robot tool slide in the +Y or –Y direction.

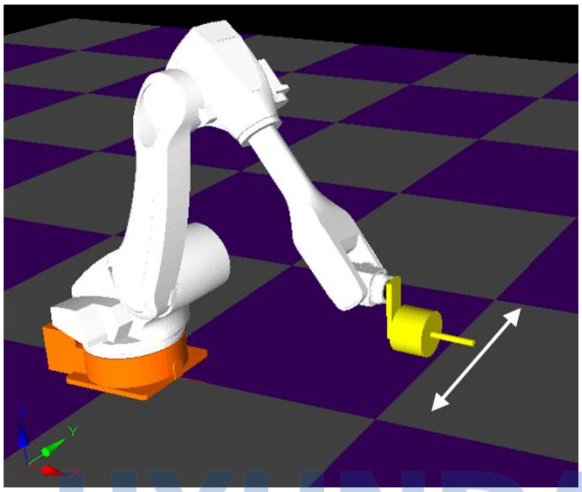

Figure 3.1 Recommendable Direction of ServoFree

(2) If the user activates the ServoFree function right after the robot has moved to a specified step, an error of estimate of the external force may be high. It is recommended to input 2-second lag time (DELAY 2.0) before activating the ServoFree function.

(3) The maximum sliding rate shall be bigger than or the same as the rate at which the robot is pushed. If the input maximum sliding rate is smaller than the rate pushing the robot, it results in an excessive external force to the robot, so it may get damaged. The possible setup of maximum sliding rate is 300mm/s.

(4) If the user pushes the robot tool that has been already pushed to the extent of the maximum sliding distance, it results in an excessive external force to the robot, so its tool may get damaged. Therefore, the user shall establish the maximum sliding distance higher than the real sliding distance. The possible setup of maximum sliding distance is 1,000mm.

(5) The robot tool may not stop and continues to slide even after the external force is zero (0) due to several effects such as a tool weight, and in this case, there is a potential collision between the robot tool and ambient equipment. Appropriate setup of the maximum sliding distance make it possible that the robot tool may stop within a certain distance even though it continues to slide without the external force.

(6) With respect to load information of tool numbers used in ServoFree teaching program, information including a gripper and work pieces which the gripper handles shall be input. If it is difficult to manually input the precise load information, using the 'Load Estimation' function comes recommended.

3.2. Examples of Handling Injection Molded Products

The job procedure of handling injection molded products with the use of the ServoFree function is as follows.

(1) Move a robot to the position of P1 so as to pick up injection molded products.
(2) Close a gripper and pick up the injection molded products.
(3) Set up initial conditions of ServoFree and activate the ServoFree function.
(4) Deliver the command of starting injection molding to the injection molding machine.
(5) While the ejector of injection molding machine is pushing the products, push the machine along in the established direction. (P1→P1')
(6) Wait for the signal which indicates the completed injection molding operation.
(7) Terminate the ServoFree function.
(8) Transport the injection molded products to the position of P2.

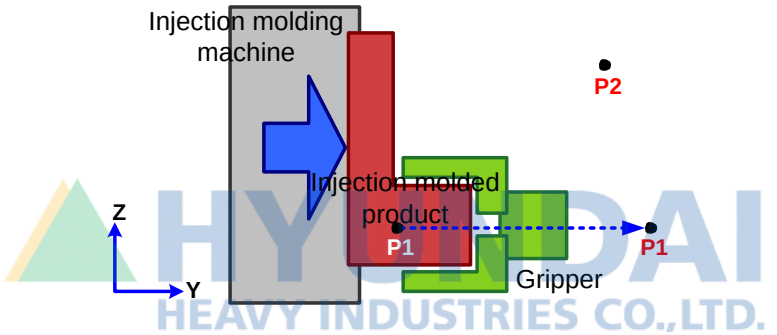

Figure 3.2 Job of Handling the Injection Molded Products

The JOB programs involved in the jobs above are as follows

Division	Program
Move to Injection Molding Machine	MOVE P,P1,S=50%,A=1,T=1
Close Gripper	DO1=1
Delay	DELAY 2.0
Set up Conditions of ServoFree & Start Functions	LIMIT POS,+Y=500 LIMIT VEL,Y=300 ServoFree ON,CRD=1,DIR=+Y,GAIN=50,F=50
Direct the Start of Injection molding	DO10=1
Completed Injection on Standby	WAIT DI1
Function Ends	ServoFree OFF
Transport the Injection Molded Product	MOVE P,P2,S=100%,A=1,T=1

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