1311, TFDEN-124-002, 001

NACHI

FD CONTROLLER INSTRUCTION MANUAL ADAPTIVE MOTION

2nd edition

- Before attempting to operate the robot, please read through this operating manual carefully, and comply with all the safety-related items and instructions in the text.
- The installation, operation and maintenance of this robot should be undertaken only by those individuals who have attended one of our robot course.
- When using this robot, observe the low related with industrial robot and with safety issues in each country.
- This operating manual must be given without fail to the individual who will be actually operating the robot.
- Please direct any queries about parts of this operating manual which may not be completely clear or any inquiries concerning the after-sale service of this robot to any of the service centers listed on the back cover.

NACHI-FUJIKOSHI CORP.

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Chapter 1 Outline

1.1 What is the “Adaptive Motion”?

1.1.1 Outline

The term “adaptive motion” represents the function of the robot to copy workpiece by external force acting on it and absorb loads.

For Example, if there is any displacement or variation in the positional relation between the robot and the jig when the robot conducts handling or assembly work, it will cause interference between the robot and the jig when mounting workpiece to the jig. Consequently, avoiding this interference needed to provide a mechanical floating mechanism, resulting in complex hand mechanism as well as increased robot weight and cost.
Using the adaptive motion function makes it possible to absorb such interference with the jig, thus requiring no floating mechanism.

The adaptive motion function is available for the following applications.

(1) Insertion
Under normal control, teaching on the inserting position and direction of workpiece should be conducted with a high level of accuracy. However, using the adaptive motion function enables the robot to insert workpiece while following holes in the jig even by rough teaching.

(2) Extraction of workpiece from a die casting machine
The adaptive motion function enables the robot to extract workpliece ejected from a die casting machine while following the operation of the die casting machine.

(3) Positioning by hitting
The adaptive motion function enables the robot to position workpiece by hitting it against the jig.

The “adaptive motion function” is option software.
Unless this option is installed, any setting screen related to the adaptive motion is not displayed.

1.1.2 Active behavior of adaptive motion

Active behaviors are broadly classified into “axis” , “orthogonal” and "Tracking" functions.
Select a proper function according to an intended application.

Table 1.1.1 List of adaptive motions

Function classification		Feature	Application example
Axis (See Note)	Softness	The movement amount of each axis is proportional to its returning force. The axis moves like a spring. This function provides smoother motion of the axis at smaller movement amount, thus making it suited to fine inserting position adjustment.	Insertion
	Torque limit	Unless a specified torque limit is applied, each axis does not move. However, when the axis exceeds the torque limit, it can continue moving at constant force. The movement amount of each axis is not proportional to its returning force. This function is suited to follow-up operations involving no relationship between position and force such as extraction of workpiece from a die casting machine. In addition, since the function is able to give constant force to workpiece, it is suited to deburring.	Extraction Deburring
Orthogonal "Machine","Tool","User", "world" + "Soft"		This function properly controls the softness of each axis in response to the posture of the robot to represent softness on the orthogonal coordinate system. Compared with "Tracking (Follow)", the position and the angle are not kept severely, but it is possible to set the softness for the X, Y, and Z axis separately. This function is suited to making the robot to follow external force and also move in a certain direction according to teaching.	Copying Insertion Extraction Flushing
Tracking (Follow) "Machine","Tool","User", "world" + "Follow"		This function controls the softness along each axis of the orthogonal coordinate system. In this function, the strength for the direction other than the designated axis is kept strong so that the position and the posture are kept. In addition, it is also possible to designate the torque limit. The softened axis is only 1 axis (X, Y, or Z).	Copying Insertion Extraction Flushing

Note: A single axis is able to control the softness and torque limit at one time.

POINT

In a case like the following, select the "Orthogonal adaptive motion".
- The posture (angle) of the tool must follow the external power.
- The parallel direction following motion along 1 or more directions are required.

In a case where the necessary direction is only 1 parallel direction along (X, Y, or Z) and strength of the position and the posture for the other direction is required, select the "Tracking adaptive motion".

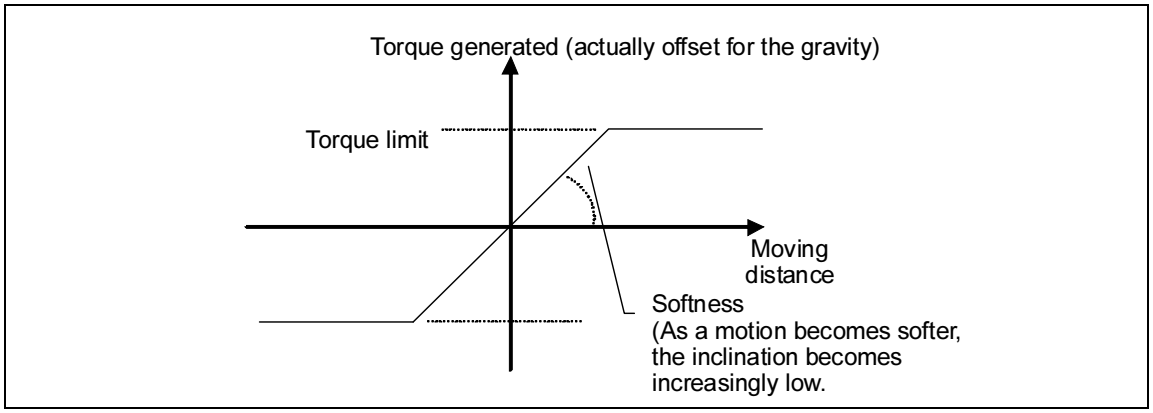


Fig. 1.1.1 Relationship between setting parameters for each axis and torque generated by motor

1.2 Precautions

The following section describes precautions for use of the adaptive motion function.

1.2.1 Preparation

Since the system is put into soft control mode while the adaptive motion is in progress, follow-up capability to commands degrades. To avoid that, torque compensation for center of gravity is made according to the settings of weight and C of G (center of gravity) parameters in the Tool Constants menu.
Consequently, use the “Automatic COG Setting Function” to make accurate settings of the weight and C of G parameters in the Tool Constants menu.

If there is a substantial difference between the weight and center of gravity of a tool actually held by the robot hand and the settings of the weight and C of G parameters in the Tool Constants menu, the arm may drop or move upward. Furthermore, such difference may cause shocks when starting or ending the adaptive motion.

CAUTION

Before executing the adaptive motion function, make accurate settings of the weight and C of G parameters in the Tool Constants menu.
Not doing so may
- cause the arm to drop or move upward; or
- cause shocks when starting or ending the adaptive motion.

1.2.2 Softness setting

Make setting of softness in the Adaptive Motion conditions menu in the range of 0% to 100%. However, setting the softness parameter to approximately 95% or more will significantly reduce force returning to the command position. Consequently, in case of an imbalance in the center of gravity, the arm may gradually drop or move upward.

Use softness of 95% or more for applications that apply such softness only in the axial direction that applies no center or gravity or supports the robot arm and tool.
In addition, be sure to make setting of the “Error distance” parameter in order to prepare for accidental motions.
For the setting procedure, refer to information in “2.2 Setting of Adaptive Motion Conditions”.

CAUTION

Use softness of 95% or more for applications that apply such softness only in the direction that applies no center of gravity or supports the robot arm and tool.
- In case of an imbalance in the center of gravity, the arm may drop or move upward.
- Be sure to make setting of the “Error distance” parameter in order to prepare for accidental motions.

1.2.3 Robot motion while adaptive motion is in progress

Since the system is put into soft control mode while the active motion is in progress, follow-up capability to commands degrades.
Consequently, the robot may not move following the locus taught by the work program.

Do not move the robot at high speeds while the adaptive motion is in progress.

DANGER

While the adaptive motion is ON, the motion control of the robot works with a premise that the interference with the peripheral devices etc. can happen. Therefore, the high-speed interference detection function is disabled temporally. This means that, under the adaptive motion control, the robot cannot stop when hitting or grasping humans or the other peripheral devices etc. and may result serious injury or death.

CAUTION

Since the system is put into soft control mode while the active motion is in progress, follow-up capability to commands degrades.
- The robot may not move following the locus taught by the work program.
- Do not move the robot at high speeds while the adaptive motion is in progress.

NOTE

Chapter 2 Procedure for Use

2.1 Procedure for Use of Adaptive Motion Function

2.1.1 Outline of Procedure

To use the adaptive motion function, follow the procedure shown below.
This section explains the outline of the procedure. For individual functions, refer to information in “2.2 Setting of Adaptive Motion Conditions” and “2.3 Application Commands for Adaptive Motion Function”.

1 Make setting of adaptive motion conditions.

Make setting of adaptive motion conditions according to the contents of work.
For setting of adaptive motion conditions, “axis” or “orthogonal” active motion and softness can be selected.
A maximum of 10 types of conditions can be defined.

Refer to “2.2 Setting of Adaptive Motion Conditions”.

2 Conduct teaching on work program.

Create a work program in any program.

3 Record the “FN364: Adaptive motion ON” command.

Record the application command “FN364: Adaptive motion ON (ADAPTON)” immediately before a step in which you want to start the adaptive motion.
Use the parameter of this application command to specify an adaptive motion condition number.

While the “Adaptive motion ON” command is in progress, it is also possible to record this command again and make a change to the condition number.

Refer to “2.3.1 ADAPTON: Adaptive motion ON (FN364)”.

4 Record the “FN365: Adaptive motion OFF” command.

Record the application command “FN365: Adaptive motion OFF (ADAPTOFF)” immediately after a step in which you want to end the adaptive motion.

Executing the application command “FN365: Adaptive motion OFF” will retrieve the position of the robot that is being pushed by external force and draw a locus from this position to the subsequent move command.
Consequently, the robot will never suddenly return to its original position.

Refer to “2.3.2 ADAPTOFF: Adaptive motion OFF (FN365)”.

5 Ensure the motion and make modifications to the adaptive motion conditions.

Ensure the adaptive motion and, if necessary, make modifications to the adaptive motion conditions.

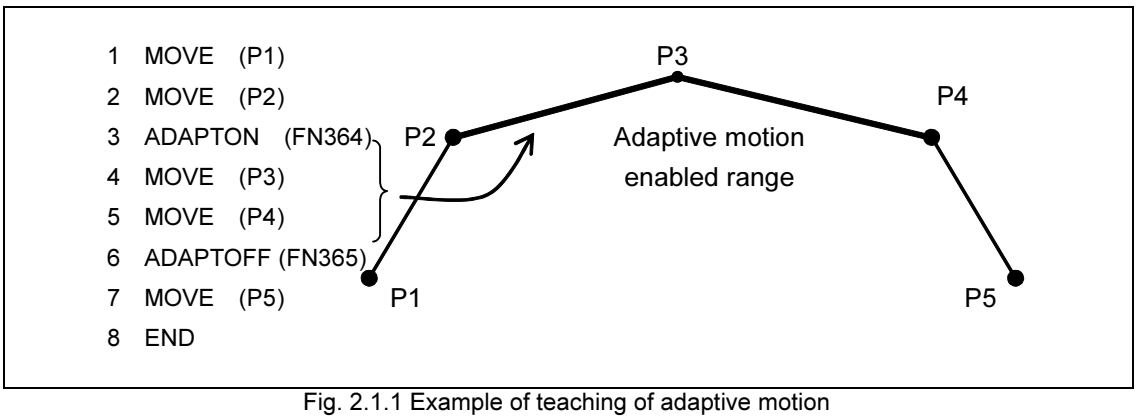


Fig. 2.1.1 Example of teaching of adaptive motion

POINT

Adaptive motion ON/OFF application commands can be recorded in program as many as you like.
In addition, while the “Adaptive motion ON” command is in progress, it is also possible to record this command again and make a change to the condition number.

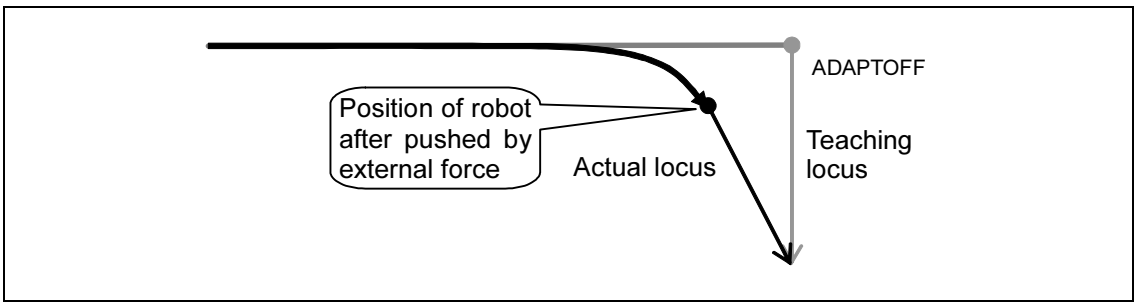


Fig. 2.1.2 Execution of “adaptive motion OFF” command

POINT

Executing the application command “FN365: Adaptive motion OFF” will retrieve the position of the robot that is pushed by external force when this command is executed and draw a locus from this position to the subsequent move command.

IMPORTANT

In case that call function command beyond unit such as CALLFAR is executed from the unit where adaptive motion is in progress, immediately after call or after return, adaptive motion condition of the last unit is kept until the next move command or delay command (FN50) is executed.
After move command or delay command (FN50) is executed, old adaptive motion condition is cleared and new adaptive motion condition of the unit in progress is applied again. (If adaptive motion is not used in this unit, free condition is applied.)

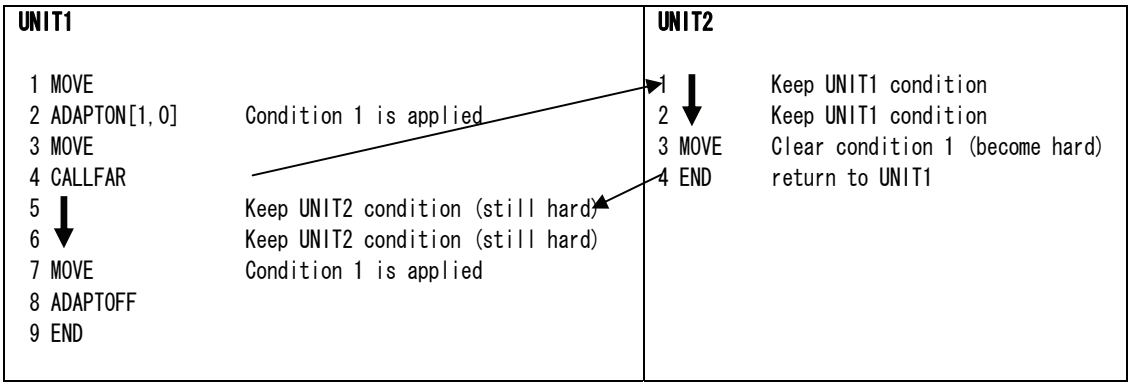


Fig 2.1.3 Example of calling beyond unit

2.1.2 Adaptive motion conditions

Make setting of softness in the Adaptive Motion conditions menu in the range of 0% to 100%. However, setting the softness parameter to approximately 95% or more will significantly reduce force returning to the command position. Consequently, in case of an imbalance in the center of gravity, the arm may gradually drop or move upward.

Use softness of 95% or more for applications that apply such softness only in the axial direction that applies no center or gravity or supports the robot arm and tool.
In addition, be sure to make setting of the “Error distance” parameter in order to prepare for accidental motions.

2.1.3 Move command

While the adaptive motion function is enabled, the move command draws the same locus as the normal locus. However, there are some differences in the locus as described below.

1. Positioning

Behavior of the robot for the positioning mark “P” is different.
If the positioning mark “P” is specified, the system will not wait for the robot to reach the recorded position, but monitor robot speeds. After the completion of outputting a command value, the robot waits for axis speed to fall below a certain level and then move to the subsequent step. This speed is automatically determined by the system so as not to give any shocks to robot while in operation.

2. Command position replacement

If the parameter “Command position replacement” of the adaptive motion ON command is set to ON, the system will retrieve the current position that has changed in response to external force when it receives a move command in the course of adaptive motion and perform a locus calculation up to the subsequent move command based on this position.
In this case, all move commands that are issued before the adaptive motion OFF command is issued operate as Accuracy A1P is specified.

For detail of the parameter “Command position replacement”, refer to information in “2.3.1ADAPTON: Adaptive motion ON (FN364)”.

2.1.4 Stopping program in progress and restarting

■ **Stopping**

If the program is stopped while the adaptive motion is enabled, the adaptive motion will become disabled to cause the robot to make an immediate stop.
Restarting the program will enable the adaptive motion again to restart playback.
However, since the system retrieves the position of the robot to which it has been pushed by external force when stopping and performs a recalculation of locus from this position to the subsequent move command for restarting, the commanded locus differs from that in the cases where the robot does not make a stop.

■ **MOTORS OFF**

If the system is put into the MOTORS OFF state due to an emergency stop or error while the adaptive motion is enabled, the adaptive motion will become disabled to cause the robot to make an immediate stop.
The adaptive motion is not enabled only by pressing the MOTORS ON pushbutton.
In this case, restarting the program will enable the adaptive motion again to restart playback.
The commanded locus for restarting is the same as that in the cases where the program is stopped in progress.

■ **END step**

Executing the END step with the adaptive motion enabled will stop the adaptive motion in progress. Restarting the system will play back the program from the beginning, but not enable the adaptive motion.
Similarly, while in continuous playback mode, when the program returns to its beginning, the adaptive motion will stop.
However, if the program returns to the beginning by executing the END step, the adaptive motion will not stop.

After the command of adaptive motion ON, the motion control of the robot works with a premise that the interference with the peripheral devices etc. can happen. Therefore, the high-speed interference detection function is disabled temporally. This means that, under the adaptive motion control, the robot cannot stop when hitting or grasping humans or the other peripheral devices etc. and may result serious injury or death.

Stopping the program in progress while the adaptive motion is enabled will return the system to the normal control.
Do not give strong external force to the robot in this state.

If the program is stopped in progress, the system will retrieve the position of the robot to which it has been pushed by external force and take it as the final command position.
For restarting, the system performs a recalculation of locus from this position to the subsequent move command. Consequently, the commanded locus differs from that in the cases where the robot does not make a stop.

2.1.5 Teaching and Check-Go

If a program in which the adaptive motion ON command is recorded with the “”Teach/Playback Condition” screen set to “All” is checked and proceeded, the adaptive motion can be enabled while in check-go mode.

Releasing the CHECK GO key will stop playback to disable the adaptive motion.
Pressing the CHECK GO key again will enable the adaptive motion again to restart check-go operation.

Axis operation cannot enable the adaptive motion.

After the command of adaptive motion ON, the motion control of the robot works with a premise that the interference with the peripheral devices etc. can happen. Therefore, the high-speed interference detection function is disabled temporally. This means that, under the adaptive motion control, the robot cannot stop when hitting or grasping humans or the other peripheral devices etc. and may result serious injury or death.

2.1.6 Stopping adaptive motion

If a program in progress is stopped while the adaptive motion is enabled, conducting any of the following operations will stop the adaptive motion. And even by restarting the program, the adaptive motion will not become enabled.

1. Selection of program
2. Playback of program from the beginning (except while in program call mode)
3. Execution of R0 (resetting of step counter)

This is the same for playback and check-go operations.

2.1.7 Limited functions

The adaptive motion puts a limit on the following functions respectively while it is enabled.

1. Energy saving

While the adaptive motion is enabled, even if the robot remains at rest, the system will not get into energy saving mode. Furthermore, executing the adaptive motion ON command while in energy saving mode will cancel the energy saving mode.
While the adaptive motion is enabled, time count until the system gets into the energy saving mode is already cleared. The time count is started as of the end of adaptive motion.

2. Returning of the previous position

If the system makes an emergency stop while the adaptive motion is enabled, it will not return to the previous position by the next pressing of the MASTER ON pushbutton.

3. Servo errors

While the adaptive motion is enabled, following servo errors are not detected on the enabled axis.
E0021 Servo follow-up fault
E0022 Deviation error
E0027 Abnormal variation in current value

While the adaptive motion ON is executed, the following servo errors are not detected.
E0026 Interference detection

DANGER

After the command of adaptive motion ON, the motion control of the robot works with a premise that the interference with the peripheral devices etc. can happen. Therefore, the high-speed interference detection function is disabled temporally. This means that, under the adaptive motion control, the robot cannot stop when hitting or grasping humans or the other peripheral devices etc. and may result serious injury or death.

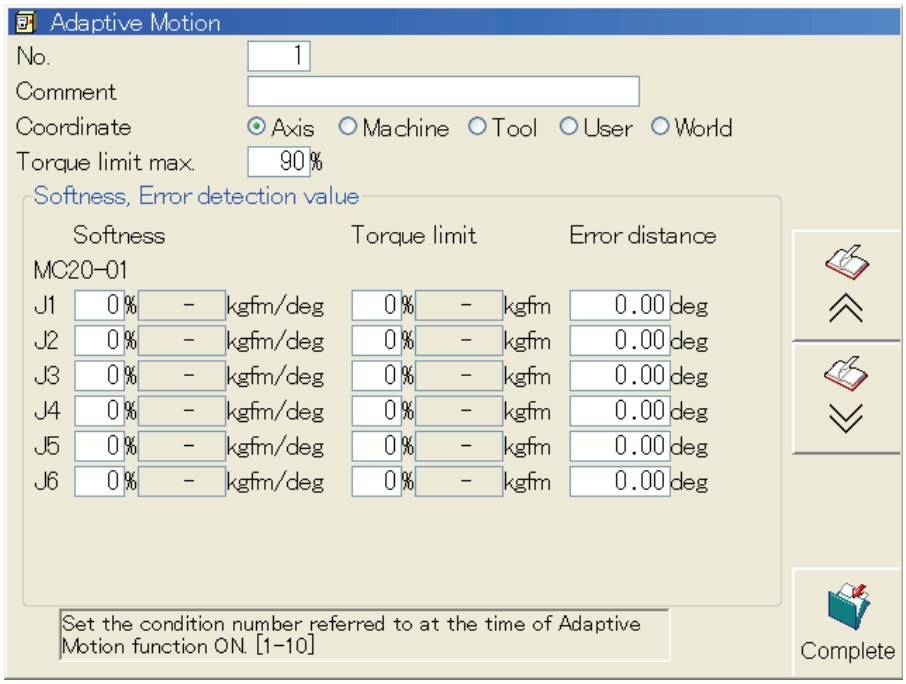
2.2 Setting of Adaptive Motion Conditions

The following section describes the procedure for making setting of adaptive motion conditions.
To make any change to this setting, set the operator class to ***EXPERT*** or higher in advance.

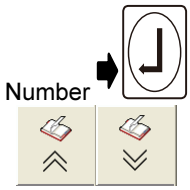
2.2.1 Procedure for making setting of adaptive motion conditions

1 **Set the Operation Mode selector switch to "TEACH".**

2 **Press the f key [Constant] to display the constant menu, and then select [39 Adaptive Motion].**
>> The following screen will appear.

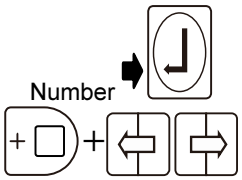


The contents shown on the screen vary depending on whether the parameter "Coordinate" is set to "Axis" or any of the other items.
For detailed settings, refer to information in
"2.2.2 Axis adaptive motion"
"2.2.3 Orthogonal adaptive motion" and
"2.2.4 Tracking adaptive motion"



3 **To make a change to the condition number, enter a number in the parameter "No." box and then press the [Enter] key, or press the [f9] or [f10] Page key.**
>> The condition number can be selected from numbers 1 to 10.
Specify the condition number set in this Step with the parameter of the application command "Adaptive motion ON", and then use the condition number.

Refer to "2.3.1 ADAPTON: Adaptive motion ON (FN364)".



4 **Put the cursor on a box of which you want to make setting, enter a numeric value, and then press the [Enter] key.**
To make setting with the use of the radio switch, press the cursor key [⇒] or [⇐] while pressing the [ENABLE] key.
>> The contents shown on the screen vary depending on whether the parameter "Coordinate" is set to Axis" or any of the other items.

For detailed settings, refer to information in "2.2.2 Axis adaptive motion" and "2.2.3 Orthogonal adaptive motion".

5 **After the completion of setting, press the f12 key [Complete].**
The set contents will be saved in the constants file.
>> Robot motions can be checked on the spot by using the setting data. The setting is saved until any change is made to it even if the power supply is turned OFF.

Table 2.2.1 Adaptive motion condition setting parameters

Parameter	Setting range	Description
No.	1 to 10	Used to make setting of a number that is referred to execute FN364 (Adaptive motion ON) command.
Comment	30 one-byte characters	Available for a comment in a maximum of 30 characters. To enter characters in the Comment box, press the [ENABLE] and [Edit] keys at one time. The comment set with this parameter is displayed in the line of FN364 (Adaptive motion ON) command in the list of programs.
Coordinate	Axis / Machine / Tool / User / World	Used to select a coordinate system that is used to specify softness. Setting this parameter to "Axis" makes it possible to specify softness by axis. Setting the parameter to "Machine, Tool, User, or World" makes it possible to specify softness on the orthogonal coordinate system. The setting on the orthogonal coordinate system is only available for 6-axes manipulator. For explanations of each item, refer to information in "2.2.2 Axis adaptive motion" and "2.2.3 Orthogonal adaptive motion".

The setting on the orthogonal coordinate system is only available for 6-axis manipulator.

2.2.2 Axis adaptive motion

The following section describes the function with the parameter “Coordinate” set to “Axis”.

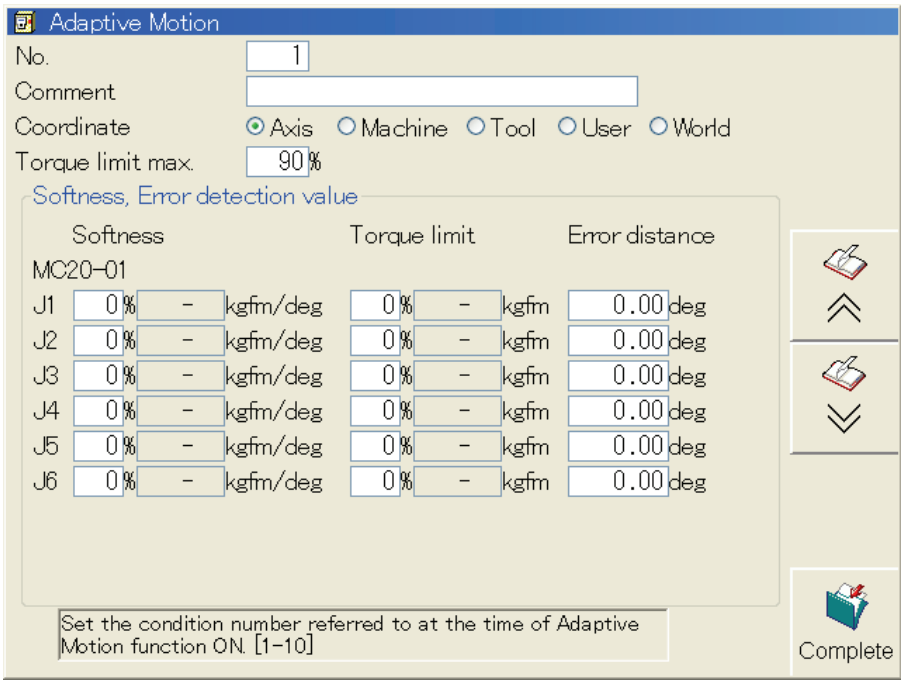


Fig. 2.2.1 Axis adaptive motion condition setting screen

The setting screen displays the items of all mechanisms registered and is available for settings of all axes of all mechanisms.

Table 2.2.2 Axis adaptive motion condition setting parameters

Parameter	Setting range	Description
Torque limit max	0 to 99%	Used to set the maximum value of [Torque limit].
Softness	0 to 100%	Used to make setting of percentage of softness. As the percentage increases, the spring constant becomes increasingly smaller and the spring becomes softer. A spring constant to the set value is displayed to the right. Setting “0” to this parameter will disable the relevant axis.
Torque limit	0 to Torque limit max	Used to make setting of torque limit. As the torque limit decreases, the maximum torque output by the motor becomes increasingly smaller, thus making it possible to operate the arm by small power. Limited torque to the set value is displayed to the right. Setting “0” to this parameter will apply no torque limit.
Error distance	Rotation axis: 0 to 90 deg. Linear axis: 0 to 1,000 mm	If the command position gets away from the current position by distance more than that set with this parameter, the error distance will be detected. This parameter setting is made in degrees for the rotation axis and millimeters for the linear axis. Setting “0” to this parameter will disable the error distance.

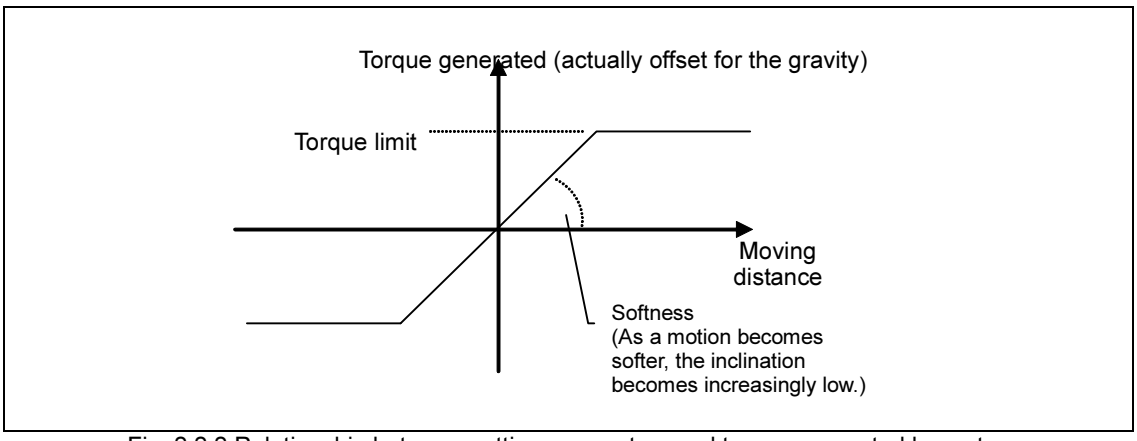


Fig. 2.2.2 Relationship between setting parameters and torque generated by motor

POINT

If the softness is set to 100%, it will be internally treated as 99.9%.
That means the robot does not operate at no load.

2.2.3 Orthogonal adaptive motion

The following section describes the function with the parameter “Coordinate” set to “Machine, Tool, User, or World”.

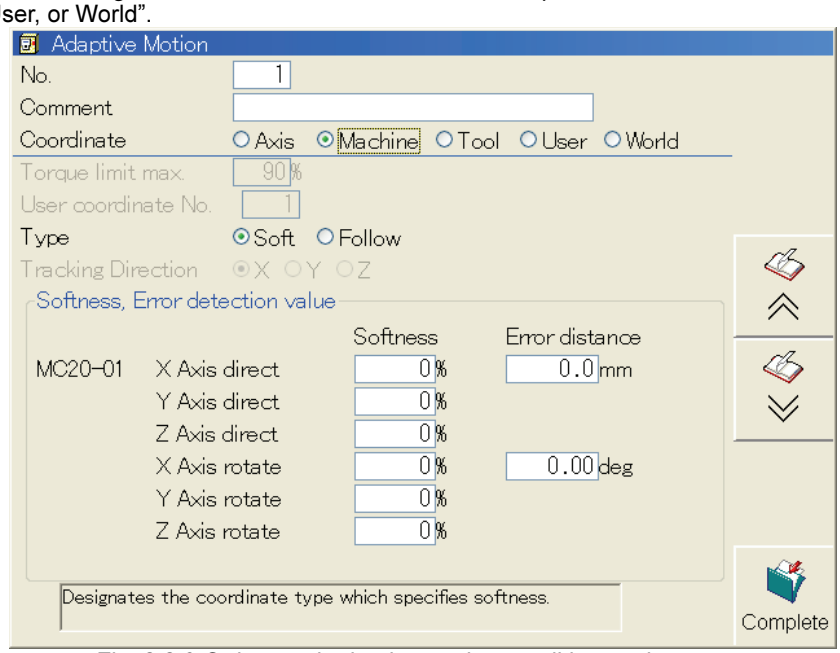
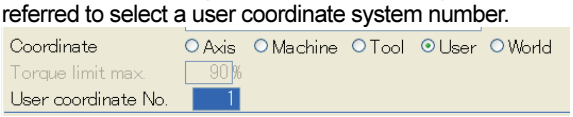


Fig. 2.2.3 Orthogonal adaptive motion condition setting screen

INFO.

The setting on the orthogonal coordinate system is only available for 6-axis manipulator.
The setting screen only displays items for the 6-axis manipulator registered.

Table 2.2.3 Orthogonal adaptive motion condition setting parameters

Parameter	Setting range	Description
User coordinate No.	1 to 100	Used to make setting of a user coordinate system number that is referred to select a user coordinate system number.  Register the user coordinate system in advance. Unless the user coordinate system is registered, the adaptive motion is conducted according to the machine coordinate system.
Softness	0 to 100%	Used to make setting of percentage of softness. As the percentage increases, the spring becomes softer. Setting “0” to this parameter will disable the adaptive motion in the relevant direction.
Error distance	[Travel distance] 0 to 1,000 [mm] [Rotation distance] 0 to 90 [deg.]	If the command TCP position gets away from the current TCP position by distance more than that set with this parameter, the error distance will be detected. The travel distance is determined by the linear distance of 3D space. For the rotation distance, the rotation axis and rotation rate of the actual TCP coordinate system to the command TCP coordinate system are found. Subsequently, the rotation distance is determined by the rotation rate found. Setting “0” to this parameter will disable the error distance.

POINT

The orthogonal adaptive action properly controls the softness of each axis (joint) in response to the postures of robot to represent the softness on the orthogonal coordinate system.
The axis may move in a direction to which 0% softness is set depending on the way of giving external force to it.

2.2.4 Tracking adaptive motion

The following section describes the function of "Tracking adaptive motion" with the parameter “Coordinate” set to “Machine, Tool, User, or World”. And, set the "Type" to "Follow".

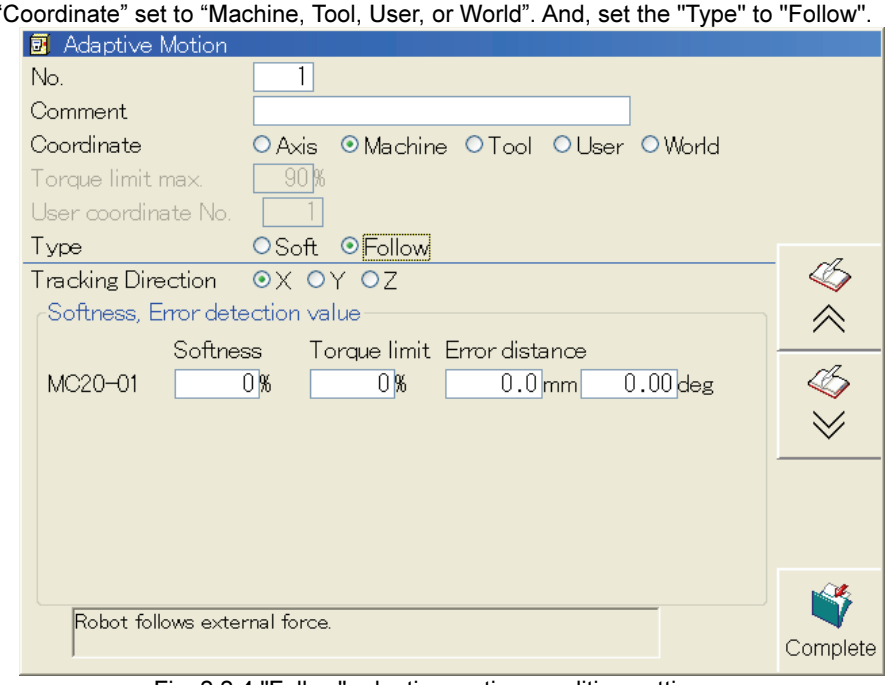


Fig. 2.2.4 "Follow" adaptive motion condition setting screen

POINT

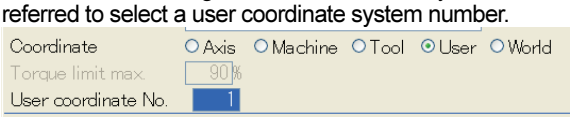
In a case like the following, select the "Orthogonal adaptive motion".
- The posture (angle) of the tool must follow the external power.
- The parallel direction following motion along 1 or more directions are required.

In a case where the necessary direction is only 1 parallel direction along (X, Y, or Z) and strength of the position and the posture for the other direction is required, select the "Tracking adaptive motion".

POINT

In the "Tracking adaptive motion", the softness for the designated axis direction is set under the defined conditions and the strength of the position and the posture for the other directions are stronger than those of the "Orthogonal adaptive motion". However, if the robot motion gets fast, the position and the posture for the other directions may change.

Table 2.2.4 "Follow" adaptive motion condition setting parameters

Parameter	Setting range	Description
User coordinate No.	1 to 100	Used to make setting of a user coordinate system number that is referred to select a user coordinate system number.  Register the user coordinate system in advance. Unless the user coordinate system is registered, the robot will stop because of error detection.
Tracking direction	X,Y,Z	Used to designate the direction in which the robot motion becomes soft and the robot follows the external power. Only parallel movement along X, Y, and Z axis can be designated. The posture rotation movement cannot be designated.
Softness	0 to 100%	Used to make setting of percentage of softness. As the percentage increases, the spring becomes softer. Setting “0” to this parameter will disable the adaptive motion in the relevant direction.

Parameter	Setting range	Description
Torque limit	0 to 100%	Used to make setting of torque limit. As this value increases, the maximum torque output by the motor becomes increasingly smaller, thus making it possible to operate the arm by small power. This is the same setting with "Axis adaptive motion". Setting “0” to this parameter will apply no torque limit.
Error distance	[Travel distance] 0 to 1000 [mm] [Rotation distance] 0 to 90 [deg]	If the command TCP position gets away from the current TCP position by distance more than that set with this parameter, the error distance will be detected. The travel distance is determined by the linear distance of 3D space. For the rotation distance, the rotation axis and rotation rate of the actual TCP coordinate system to the command TCP coordinate system are found. Subsequently, the rotation distance is determined by the rotation rate found. Setting “0” to this parameter will disable the error distance.
(Axis setting)	Auto, J1, J2, J3	This item can be set with an operator class ***SPECIALIST***. This item is used to determine the axis (joint) that will move the most when the robot is making a tracking adaptive motion. Select a main axis that will move much along the tracking direction. In a normal use, "Auto" is recommended. However, if the robot posture changes much and the axis that moves much changes to other axis while the tracking adaptive motion is being executed, the robot may stop with an error when it cannot follow the external power. In a case like that, re-select the axis according to the motion amount.

POINT While the "Tracking adaptive motion" is being executed, slow posture change is possible. But, please avoid a fast posture change. If the posture is changed fast, the robot cannot follow the external power and may stop because of error detection.

POINT Even if the "Tracking adaptive motion" is being executed, the setting for the "Axis adaptive motion" is still effective. In short, it is possible to soften not only the axis designated in this screen but also the other axes.

2.3 Application Commands for Adaptive Motion Function

2.3.1 ADAPTON: Adaptive motion ON (FN364)

This is an application command to start the adaptive motion.

Mnemonic	Number	Command name
ADAPTON	FN364	Adaptive motion ON

Parameters

Parameter	Data	Function / Setting range
Parameter 1	Condition number	Used to specify adaptive motion condition number (1 to 10). Make setting of adaptive motion condition on the "Constants → 39 Adaptive Motion" screens.
Parameter 2	Command position replacement ON / OFF (1 / 0)	0: Used to perform a locus calculation as per normal when the system receives a move command in the course of adaptive motion. 1: Used to retrieve the current position that has changed in response to external force when the system receives a move command in the course of adaptive motion and perform a locus calculation up to the subsequent move command based on this position.

■ About command position replacement

If the parameter "Command position replacement" is set to "OFF", the commanded locus will be exactly the same as the normal locus.

If the parameter "Command position replacement" is set to ON, the system will retrieve the current position that has changed in response to external force when it receives a move command in the course of adaptive motion and perform a locus calculation up to the subsequent move command based on this position.

In this case, all move commands that are issued before the adaptive motion OFF command is issued operate assuming that Accuracy A1P is specified.

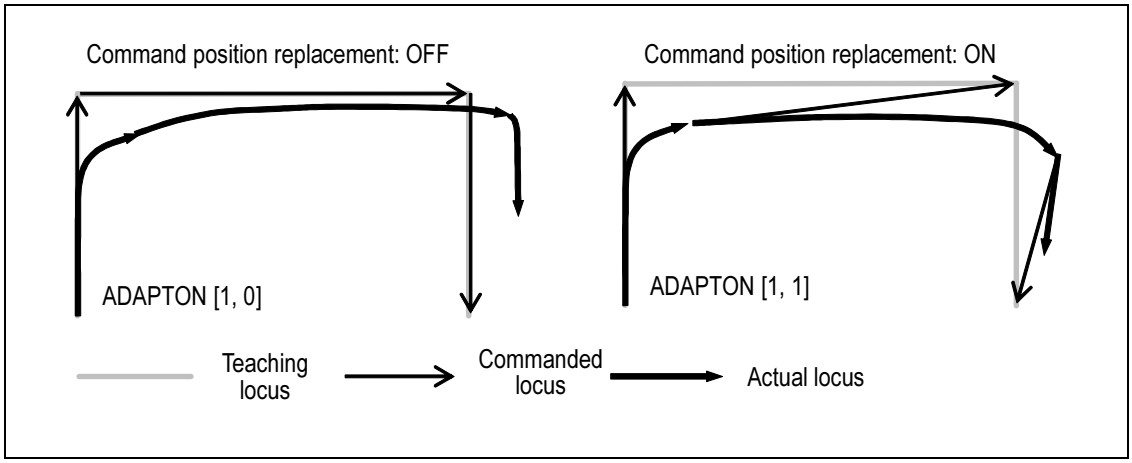


Fig. 2.3.1 Difference in locus between command position replacement ON and OFF

INFO.

While the "Adaptive motion ON" command is in progress, it is also possible to record this command again and make a change to the condition number.
In this case, command position replacement occurs in the adaptive motion ON recording stage regardless of whether the parameter "Command position replacement" is set to ON or OFF.

POINT

A distance from the command value is proportional to force trying to return. In this connection, note that if command position replacement occurs, the distance from the command value will come to "0", and consequently the force trying to return will also come to "0".
If the robot hits against an fixed object, the command position replacement will eliminate loads applied to the robot, thus making it effective. In contrast, if the robot supports force from a moving object, the command position replacement will disturb the balance of force. Consequently, the robot may make sudden movements.

2.3.2 ADAPTOFF: Adaptive motion OFF (FN365)

This is an application command to end the adaptive motion.

Mnemonic	Number	Command name
ADAPTOFF	FN365	Adaptive motion OFF

Parameters
None

The application command “Adaptive motion OFF” is executed after the speed of each robot axis (joint) falls below a certain level. The reason is that changing control while in operation may result in shocks or servo errors. This speed is automatically determined by the system.

Executing the application command “Adaptive motion OFF” will retrieve the position of the robot that is being pushed by external force and draw a locus from this position to the subsequent move command. Consequently, the robot will never suddenly return to its original position.
This is the same regardless of whether the parameter “command position replacement” is set to ON or OFF in order to execute the application command “Adaptive motion ON”.

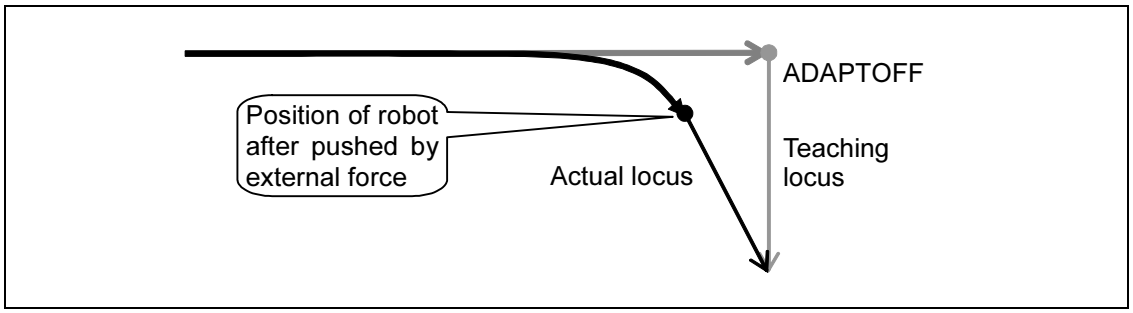


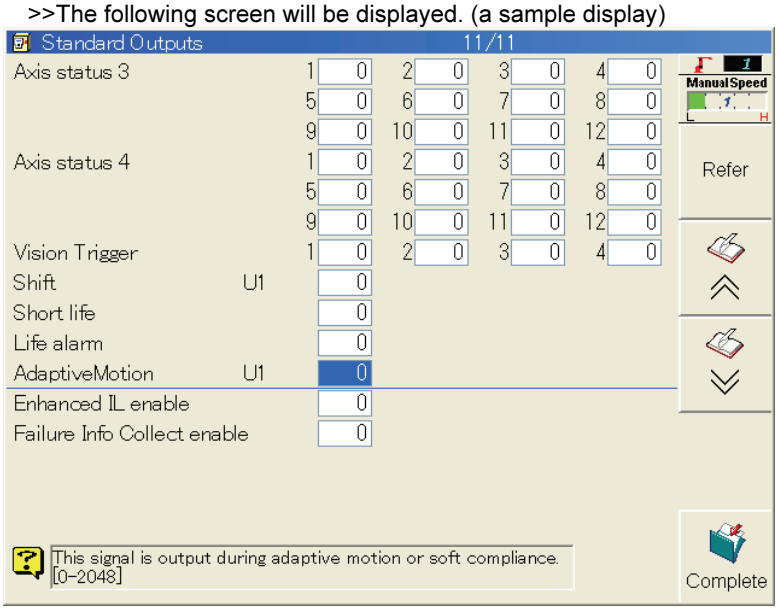
Fig. 2.3.2 Execution of “adaptive motion OFF” command

2.4 Signal output while the adaptive motion is being used

"Adaptive Motion" signal can be outputted while the adaptive motion function is being executed.
(This is a shared signal with Soft compliance function.)

1 Open [Constant Setting][6 Signals][3 Output signal assignment][1 Standard Outputs]

>>The following screen will be displayed. (a sample display)



"Adaptive Motion" signal can be assigned per unit.

Table 2.4.1 Signal assignment

Parameter	Set value when shipped	Setting range	Description of function
Adaptive Motion	0	0 to 2048	・When ADAPTON[FN364] is executed, this signal turns ON. When ADAPTOFF[FN365] is executed, this signal turns OFF. ・This signal will not be turned OFF by the following conditions. When the playback is stopped When the CHECK GO operation is stopped When the Enable switch is released ・This signal will be turned OFF by the following conditions. Step selection operation is executed (Including [R],[0],[Enter] operation) Program selection operation Execution of step 0 Execution of END function ・If a program is called by CALLP function etc. and a step 0 or END function is executed in the program, the signal will not be turned OFF.

NOTE

Chapter 3 Troubleshooting

3.1 Error Messages

E1823: This function cannot be used concurrently with adaptive motion.

[Cause] A function that is not allowed to use while the adaptive motion is in progress was used.
[Countermeasure] Review the work program, and then use the function in a step that is not included in the adaptive motion range.

E1824: Error distance caused in the adaptive motion function due to external force

[Cause] If the command position gets away from the current position by distance or angle more than that set on the “Constants → 39 Adaptive Motion” screens while the adaptive motion function is enabled, the error distance will be detected.
[Countermeasure] Review the adaptive motion conditions.

E1825: No interpolation points can be provided due to peculiar posture.

[Cause] The robot cannot clear the peculiar posture (pass through the dead zone of the J5 axis) while in adaptive motion follow-up operation.
[Countermeasure] Review the work program to avoid passing through the dead zone of the J5 axis.

NOTE

Chapter 4 Supplemental

4.1 Adjustment of operating characteristics

The adaptive motion function has constant set values relating to operating characteristics. These set values are not normally needed to change. However, making adjustment of them enables adjustment of the operating characteristics.

Particularly, since additional axes are available in a variety of patterns, there can be cases where the patterns cannot be covered just by the default value. In such cases, make adjustment of the constant setting.

Table 4.1.1 Machine constant for adaptive motion

Constant setting	Set value when shipped	Setting range	Description of function
ADTM integration circuit limiter	200	0 to 1000	Used to make setting of output limit value of the integration circuit while the adaptive motion function is enabled. As this value becomes larger, it becomes increasingly easier to match the actual machine position with the command value when external force is lost. However, too large value loses softness.

POINT

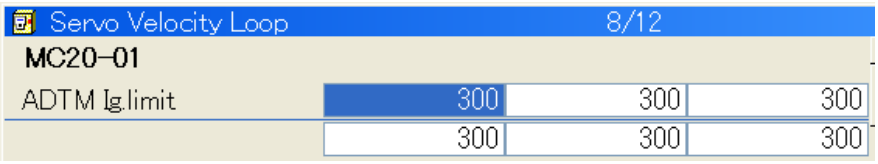
If the machine constant is set to “0”, the adaptive motion will operate assuming that the constant is set to the “Set value when shipped” of above table. If the constant is set to any value other than “0”, the adaptive motion will operate at the relevant set value.

4.1.1 Setting procedure

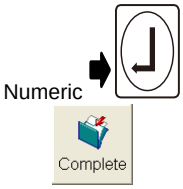
1 Set the Operation Mode selector switch to “TEACH”.

2 Set the operator class to *SPECIALIST*.
The operator class *EXPERT* is not available for making changes to manipulator mechanism setting

3 Press the f key [Constant] to display the constant menu, and then select [3 Machine constant] → [12 Servo Velocity Loop].
>> Feed pages using the Page key and display the window of “Table 4.1.2 Machine constant for adaptive motion”.



4 If multiple mechanisms are registered, display the objective mechanism setting.



5 Enter a numeric value in the entry box, and then press the f12 key [Complete].

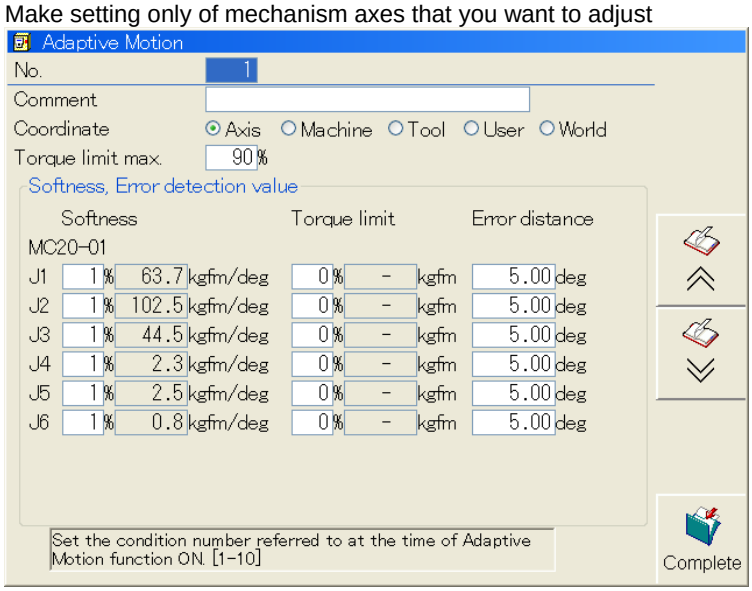
CAUTION

Do not make any change to set value other than that listed in Table 4.1.1 Machine constant for adaptive motion.

4.1.2 Checking of “ADTM integration circuit limiter” for effect

Create adaptive motion conditions and program used for checking, and then check whether the system promptly returns to the command values if external force is lost.

1 **Set the parameter “Coordinate” to “Axis” and softness to 1% for all axes.**
Make setting only of mechanism axes that you want to adjust



2 **Create a program used for checking.**

With the adaptive motion function enabled, make the robot slowly hit against an object and retreat.

```
1 MOVE              ← Record in the vicinity of object against which the robot hits.
2 ADAPTON[1,0] FN364
3 MOVE              ← Robot to slightly hit against the object.
4 MOVE              ← Robot to return to the original position.
5 WAITI [I1]        ← System to be put into I-wait mode in a state in which it is
                      released from external force.
6 ADAPTOFF  FN365
7 END
```

Fig. 4.1.1 Example of program used for checking

3 **Display the axis monitor.**
Select [Monitor 2 (or 3 or 4)] and [2-axis monitor].

4 **Play back the program.**
The system will be put into I-wait mode in a state in which it is released from external force in Step 4.
In this state, monitor the “command value” and “current value” on the axis monitor, and ensure that a difference between these values comes to below “32”.

5 **If the difference does not come to below “32”:**
Return to “4.1.1 Setting procedure”, and then increase the value of “ADTM integration circuit limiter”.
Increasing the value in increments of approximately 100 is enough.

POINT The difference may not fall within “32” depending on the characteristics of mechanism or reduction gear. If the difference shows no changes even by increasing the values, it is acceptable to complete adjustment at that point.

POINT There are some cases where axes to which center of gravity is applied are hard to match with the command value.
In such cases, check the tool constant for setting of the Weight and C of G parameters.

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