EPSON

EPSON RC+ 7.0 Option

Force Guide 7.0

SPEL+ Language Reference

Rev.9 EM208S4423F

EPSON RC+ 7.0 Option　Force Guide 7.0　SPEL+ Language Reference　Rev.9

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FOREWORD

Thank you for purchasing our robot products. This manual contains the information necessary for the correct use of the Force Guide 7.0.
Please carefully read this manual and other related manuals when using this software.
Keep this manual in a handy location for easy access at all times.

WARRANTY

The robot and its optional parts are shipped to our customers only after being subjected to the strictest quality controls, tests and inspections to certify its compliance with our high performance standards.
Product malfunctions resulting from normal handling or operation will be repaired free of charge during the normal warranty period. (Please contact the supplier of your region for warranty period information.)
However, customers will be charged for repairs in the following cases (even if they occur during the warranty period):

1. Damage or malfunction caused by improper use which is not described in the manual, or careless use.

2. Malfunctions caused by customers' unauthorized disassembly.

3. Damage due to improper adjustments or unauthorized repair attempts.

4. Damage caused by natural disasters such as earthquake, flood, etc.

Warnings, Cautions, Usage:

1. If the robot or associated equipment is used outside of the usage conditions and product specifications described in the manuals, this warranty is void.

2. If you do not follow the WARNINGS and CAUTIONS in this manual, we cannot be responsible for any malfunction or accident, even if the result is injury or death.

3. We cannot foresee all possible dangers and consequences. Therefore, this manual cannot warn the user of all possible hazards.

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TRADEMARK NOTIFICATION IN THIS MANUAL

Microsoft® Windows® 8 Operating system

Microsoft® Windows® 10 Operating system

Throughout this manual, Windows 8 and Windows 10 refer to above respective operating systems. In some cases, Windows refers generically to Windows 8 and Windows 10.

NOTICE

No part of this manual may be copied or reproduced without authorization.
The contents of this manual are subject to change without notice.
Please notify us if you should find any errors in this manual or if you have any comments regarding its contents.

MANUFACTURER

SEIKO EPSON CORPORATION

CONTACT INFORMATION

Contact information is described in “SUPPLIERS” in the first pages of the following manual:

Robot System Safety and Installation Read this manual first

SAFETY PRECAUTIONS

Installation of robots and robotic equipment should only be performed by qualified personnel in accordance with national and local codes. Please carefully read this manual and other related manuals when using this software.
Keep this manual in a handy location for easy access at all times.

Table of Contents

Summary

This reference manual explains the Force Guide 7.0 object properties and status, as well as all of the Force Guide 7.0 SPEL+ commands.

Refer to the following manual for how to use Force Guide 7.0.

EPSON RC+ 7.0 Option Force Guide 7.0

Explanation of Force Guide 7.0 Properties and Statuses Format

This manual explains all Force Guide 7.0 properties and statuses. The items explained on each reference page are as follows.

Application	When Property or Status is used with Force Object, this indicates which respective properties are applied to which force object. (Examples: Force Coordinate System Object FCS#, Force Control Object FC#, Force Trigger Object FT#, Force Monitor Object FM#...)
Comments	Contains a simple explanation of each property or status.
Immediate Execution	When "Yes": Reflected in motion directly after execution in the FSet string When "No": After the properties are set and the motion command is executed, the motion, reflecting the established properties, is executed
Usage	Explains the SPEL+ Language property, or the method to access the status SPEL
Values	Explains the range for values which can be set in properties, or explains the range of the status return value
Detailed Explanation	This gives greater detail than that which is contained in the comments. Specific warnings and special instructions are given for each property. Be sure to read this prior to using that property.
Usage Example	This gives usage examples for properties, statuses, functions, statements and commands.
Reference	This lists related properties, statuses, force objects, and other related items.

Force Guide 7.0 Command Table

Robot Control Related Commands

FCKeep	Activates the force control function, and when the specified amount of time has elapsed, a stop is executed.
FCEnd	Stops the active force control function.
GetRobotFCOn	Returns the robot number of the robot executing the force control function.
FCOn	Determines if the specified robot is executing the force control function.
Move	Activates force control and executes a linear interpolation motion.
TMove	Executes an offset linear interpolation motion in the current tool coordinate system with the force control function active.
BMove	This executes in the local selected coordinate system an offset linear interpolation motion with the force control active.
CVMove	Activates force control and executes a free curve CP motion.
Arc3	Moves the robot in a circular interpolation motion in 3 dimensions with the force control active.
Arc	Moves the robot in a circular interpolation motion in the XY plane with the force control active.
FCSMove	Executes an offset linear interpolation motion in the specified force coordinate system.

Force Object Related Commands

FGet	This is used when acquiring the properties or status of a force object.
FSet	Used when setting the value of force object properties.
FLoad	Loads all force objects from the disc into the current project.
FSave	Saves all force objects from the current project to the disc.
FExport	Exports the project force files for the project currently selected.
FImport	Imports force files into the currently selected robot project.
FDef	Indicates whether the force object is defined or not.
FDel	Deletes the force object.
FList	Displays a list of objects.
FLabel$	Returns the label for the force object and the force sensor object.
FNumber	Returns the number of the force object by type.

Mass Property Object Related Commands

MPGet	Used when obtaining the Mass Property Object value.
MPSet	Used when setting the Mass Property Object value.
MP	Sets or returns the number for the Mass Property Object to be used.
MPDef	Indicates whether the Mass Property Object is defined or not.
MPDel	Deletes the Mass Property Object.
MPList	Displays a list of Mass Property Objects.
MPNumber	Returns the number of the Mass Property Object.
MPLabel$	Returns the Mass Property Object label.

Coordinate Conversion Related Commands

F_FlangeOffset	This sets or returns the force sensor position and orientation in the Tool 0 (TCP0, J6 flange) coordinate system.
F_GravityDirection	Sets or returns the direction of gravity for the robot
F_DestPos	Returns the virtual destination position before correction by force control function.
F_RefPos	Returns the current virtual command position f before correction by force control function.
F_OffsetPos	Returns the position of relative movement from the reference point.

Force Guidance Related Commands

FGRun	Executes a force guide sequence.
FGGet	Acquires a result of a force guide sequence or a force guide object.

Force Object - Common

Comments

A force object is an object (collectively) used when using the force function. The following are the types of objects.

Force Control Object (FC)

Force Trigger Object (FT)

Force Coordinate System (FCS)

Force Monitor Object (FM)

Label	Sets or returns the object label.
Number	Sets or returns the number of the object by type.
Description	Sets or returns an explanation for an object.

FS (Force Sensor) Object

Comments

This is a force sensor related object (collectively). It is used to control the sensor and obtain data, etc.

Range

FS1 to FS4

Reset	Resets the force sensor.
Reboot	Reboots the force sensor.

Label	Returns the force sensor label.
Description	Displays an explanation of the force sensor.
Model	Returns the model name of the force sensor.
SerialCode	Returns the serial code for the force sensor.

FCS (Force Coordinate System) Object

Comments

This object (collectively) is used to convert the coordinate system in the direction of the user set values for force and torque.

FCS0 corresponds to the set leading point of the tool.

Range

FCS0 to FCS63

However, FCS0 corresponds to the coordinate system of the selected tool and cannot be modified.

Position	Sets or returns the force coordinate origin.
Orientation	Sets or returns the orientation of the force coordinate coordinate-axis.

Reference

EPSON RC+ User's Guide

6.16 Coordinate Systems

6.18 Robot Motion Commands

Robot Object

Comments

This object (collectively) is used to establish the installation settings for the robot to which the force sensor is installed, or for the purpose of obtaining data when the robot is operating / moving.

FlangeOffset	Sets the positional relationship between Tool 0 (TCP0, J6 Flange) and the force sensor position.
GravityDirection	Sets or returns the direction of gravity for the robot.
StepID	Sets or returns the robot object StepID.
RefPos	Returns the command position for the first variable, including the force control. Returns only the command position for the second variable, disregarding the effect of the force control.

FC (Force Control) Object

Comments

This object (collectively) is used to fix the movement properties when executing the force control function.

Range

FC0 to FC999

CoordinateSystem	Returns or sets the force coordinates.
Fx_Enabled, Fy_Enabled, Fz_Enabled	Independently activates/inactivates, or returns the force control function of the translational direction.
Tx_Enabled, Ty_Enabled, Tz_Enabled	Independently activates/inactivates, or returns the force control function of the rotational direction.
Enabled	Activates/inactivates, or returns the force control function for each axis collectively.
Fx_Mass	Sets or returns the virtual coefficient of inertia for the force control on the X axis in the direction of the translational force.
Fx_Damper	Sets or returns the virtual coefficient of viscosity for the force control on the X axis in the direction of the translational force.
Fx_Spring	Sets or returns the virtual coefficient of elasticity for the force control on the X axis in the direction of the translational force.
Fx, Fy, Fz, Tx, Ty, Tz	Sets or returns the virtual coefficient of elasticity, the virtual coefficient of viscosity, and the virtual coefficient of inertia for the force control on the specified axis of the force coordinates.
Fy_Mass	Sets or returns the virtual coefficient of inertia for the force control on the Y axis in the direction of the translational force.
Fy_Damper	Sets or returns the virtual coefficient of viscosity for the force control on the Y axis in the direction of the translational force.
Fy_Spring	Sets or returns the virtual coefficient of elasticity for the force control on the Y axis in the direction of the translational force.
Fz_Mass	Sets or returns the virtual coefficient of inertia for the force control on the Z axis in the direction of the translational force.
Fz_Damper	Sets or returns the virtual coefficient of viscosity for the force control on the Z axis in the direction of the translational force.
Fz_Spring	Sets or returns the virtual coefficient of elasticity for the force control on the Z axis in the direction of the translational force.
Tx_Mass	Sets or returns the virtual coefficient of inertia for the force control in the rotational direction around the X axis.
Tx_Damper	Sets or returns the virtual coefficient of viscosity for the force control in the rotational direction around the X axis.
Tx_Spring	Sets or returns the virtual coefficient of elasticity for the force control in the rotational direction around the X axis.
Ty_Mass	Sets or returns the virtual coefficient of inertia for the force control in the rotational direction around the Y axis.
Ty_Damper	Sets or returns the virtual coefficient of viscosity for the force control in the rotational direction around the Y axis.

Ty_Spring	Sets or returns the virtual coefficient of elasticity for the force control in the rotational direction around the Y axis.
Tz_Mass	Sets or returns the virtual coefficient of inertia for the force control in the rotational direction around the Z axis.
Tz_Damper	Sets or returns the virtual coefficient of viscosity for the force control in the rotational direction around the Z axis.
Tz_Spring	Sets or returns the virtual coefficient of elasticity for the force control in the rotational direction around the Z axis.
TargetForcePriorityMode	Activates/inactivates or returns the target force priority mode.
Fx_TargetForce	Sets or returns the target force on the X axis in the direction of the translational force.
Fy_TargetForce	Sets or returns the target force on the Y axis in the direction of the translational force.
Fz_TargetForce	Sets or returns the target force on the Z axis in the direction of the translational force.
Tx_TargetForce	Sets or returns the target torque in the rotational direction around the X axis.
Ty_TargetForce	Sets or returns the target torque in the rotational direction around the Y axis.
Tz_TargetForce	Sets or returns the target torque in the rotational direction around the Z axis.
TargetForces	Simultaneously sets or returns the target force and target torque for each of the six axes.
MotionLimited	Returns the velocity and acceleration limits during force control.
LimitSpeedS	Sets or returns the maximum velocity limit for tool position change during force control.
LimitSpeedR	Sets or returns the maximum velocity limit for tool orientation change during force control.
LimitSpeedJ	Sets or returns the maximum velocity limit for joint movement during force control.
LimitSpeedSRJ	Sets or returns the maximum velocity limit for tool position change, tool orientation change, and joint movement during force control.
LimitAccelS	Sets or returns the maximum acceleration limit for tool position change during force control.
LimitAccelR	Sets or returns the maximum acceleration limit for tool orientation change during force control.
LimitAccelJ	Sets or returns the maximum acceleration limit for joint movement during force control.
LimitAccelSRJ	Sets or returns the maximum acceleration limit for tool position change, tool orientation change, and joint movement during force control.

FT (Force Trigger) Object

Comments

This object (collectively) is used for changing the movement path based on the value from the force sensor, and for use with conditional branches.

Range

FT0 to FT999

ForceSensor	Sets or returns the number of the force sensor in question.
CoordinateSystem	Returns or sets the force coordinates.
TriggerMode	Sets or returns the object of the force trigger monitor.
Operator	Sets or returns the trigger conditions.
Fmag_Axes	Sets or returns the subject axis for calculating the resultant force.
Tmag_Axes	Sets or returns the subject axis for calculating the resultant torque.
Fx_Enabled, Fy_Enabled, Fz_Enabled	Independently activates/inactivates, or returns the force trigger of the translational direction.
Tx_Enabled, Ty_Enabled, Tz_Enabled	Independently activates/inactivates, or returns the force trigger of the rotational direction.
Fmag_Enabled	Activates/inactivates or returns the force trigger based on Fmag resultant force.
Tmag_Enabled	Activates/inactivates or returns the force trigger based on Tmag resultant torque.
Enabled	Activates/inactivates, or returns the force trigger for each axis collectively.
Fx_Polarity	Sets or returns for Fx whether the force trigger is activated or inactivated when values correspond to or do not correspond with threshold values.
Fy_Polarity	Sets or returns for Fy whether the force trigger is activated or inactivated when values correspond to or do not correspond with threshold values.
Fz_Polarity	Sets or returns for Fz whether the force trigger is activated or inactivated when values correspond to or do not correspond with threshold values.
Tx_Polarity	Sets or returns for Tx whether the force trigger is activated or inactivated when values correspond to or do not correspond with threshold values.
Ty_Polarity	Sets or returns for Ty whether the force trigger is activated or inactivated when values correspond to or do not correspond with threshold values.
Tz_Polarity	Sets or returns for Tz whether the force trigger is activated or inactivated when values correspond to or do not correspond with threshold values.
Fmag_Polarity	Sets or returns for resultant force whether the force trigger is activated or inactivated when values correspond to or do not correspond with threshold values.
Tmag_Polarity	Sets or returns for resultant torque whether the force trigger is activated or inactivated when values correspond to or do not correspond with threshold values.
Polarities	Sets or returns for each axis whether the force trigger is activated or inactivated when values correspond to or do not correspond with threshold values.
Fx_Levels	Sets or returns the upper and lower threshold values for Fx force.

Fy_Levels	Sets or returns the upper and lower threshold values for Fy force.
Fz_Levels	Sets or returns the upper and lower threshold values for Fz force.
Tx_Levels	Sets or returns the upper and lower threshold values for Tx torque.
Ty_Levels	Sets or returns the upper and lower threshold values for Ty torque.
Tz_Levels	Sets or returns the upper and lower threshold values for Tz torque.
Fmag_Levels	Sets or returns the upper and lower threshold values for resultant force.
Tmag_Levels	Sets or returns the upper and lower threshold values for resultant torque.
UpperLevels	Sets or returns the upper threshold values for force and torque for each axis simultaneously.
LowerLevels	Sets or returns the lower threshold values for force and torque for each axis simultaneously.
Fx_LPF_Enabled	Activates/inactivates or returns the low-pass filter applied to the force in the X axis in the direction of translation.
Fy_LPF_Enabled	Activates/inactivates or returns the low-pass filter applied to the force in the Y axis in the direction of translation.
Fz_LPF_Enabled	Activates/inactivates or returns the low-pass filter applied to the force in the Z axis in the direction of translation.
Tx_LPF_Enabled	Activates/inactivates or returns the low-pass filter applied to the torque around the X axis.
Ty_LPF_Enabled	Activates/inactivates or returns the low-pass filter applied to the torque around the Y axis.
Tz_LPF_Enabled	Activates/inactivates or returns the low-pass filter applied to the torque around the Z axis.
Fmag_LPF_Enabled	Activates/inactivates or returns the resultant force low-pass filter.
Tmag_LPF_Enabled	Activates/inactivates or returns the resultant torque low-pass filter.
LPF_Enabled	Activates/inactivates or returns the low-pass filters applied to each axis simultaneously.
Fx_LPF_TimeConstant	Sets or returns the time constant for the low-pass filter applied to the force in the X axis in the direction of translation.
Fy_LPF_TimeConstant	Sets or returns the time constant for the low-pass filter applied to the force in the Y axis in the direction of translation.
Fz_LPF_TimeConstant	Sets or returns the time constant for the low-pass filter applied to the force in the Z axis in the direction of translation.
Tx_LPF_TimeConstant	Sets or returns the time constant for the low-pass filter applied to the torque around the X axis.
Ty_LPF_TimeConstant	Sets or returns the time constant for the low-pass filter applied to the torque around the Y axis.
Tz_LPF_TimeConstant	Sets or returns the time constant for the low-pass filter applied to the torque around the Z axis.
Fmag_LPF_TimeConstant	Sets or returns the time constant for the low-pass filter applied to the resultant force.
Tmag_LPF_TimeConstant	Sets or returns the time constant for the low-pass filter applied to the resultant torque.
LPF_TimeConstants	Sets or returns the time constant for the low-pass filter applied to each axis simultaneously.

Triggered	Returns the status/condition of the force trigger.
TriggeredAxes	Returns the forced/not forced status of force triggers by axis.
TriggeredPos	Returns the met position for the force trigger conditions.
TriggeredForces	Returns force and torque when end conditions of force trigger are achieved.

FM (Force Monitor)Object

Comments

This object (collectively) is used to display the value from the force sensor and when recording that value.

Range

FM0 to FM255

ForceSensor	Sets or returns the number of the force sensor in question.
CoordinateSystem	Returns or sets the force coordinates.
RobotLocal	Sets or returns the local coordinate system that will serve as the basis for robot positions.
RobotTool	Sets or returns the tool coordinate system that will serve as the basis for robot positions
Fmag_Axes	Sets or returns the subject axis for calculating the resultant force.
Tmag_Axes	Sets or returns the subject axis for calculating the resultant torque.
Fx_LPF_Enabled	Activates/inactivates or returns the low-pass filter applied to the force in the X axis in the direction of translation.
Fy_LPF_Enabled	Activates/inactivates or returns the low-pass filter applied to the force in the Y axis in the direction of translation.
Fz_LPF_Enabled	Activates/inactivates or returns the low-pass filter applied to the force in the Z axis in the direction of translation.
Tx_LPF_Enabled	Activates/inactivates or returns the low-pass filter applied to the rotational force around the X axis.
Ty_LPF_Enabled	Activates/inactivates or returns the low-pass filter applied to the rotational force around the Y axis.
Tz_LPF_Enabled	Activates/inactivates or returns the low-pass filter applied to the rotational force around the Z axis.
Fmag_LPF_Enabled	Activates/inactivates or returns the resultant force low-pass filter.
Tmag_LPF_Enabled	Activates/inactivates or returns the resultant torque low-pass filter.
LPF_Enabled	Activates/inactivates or returns the low-pass filters applied to each axis simultaneously.
Fx_LPF_TimeConstant	Sets or returns the time constant for the low-pass filter applied to the force in the X axis in the direction of translation.
Fy_LPF_TimeConstant	Sets or returns the time constant for the low-pass filter applied to the force in the Y axis in the direction of translation.
Fz_LPF_TimeConstant	Sets or returns the time constant for the low-pass filter applied to the force in the Z axis in the direction of translation.
Tx_LPF_TimeConstant	Sets or returns the time constant for the low-pass filter applied to the rotational force around the X axis.
Ty_LPF_TimeConstant	Sets or returns the time constant for the low-pass filter applied to the rotational force around the Y axis.
Tz_LPF_TimeConstant	Sets or returns the time constant for the low-pass filter applied to the rotational force around the Z axis.
Fmag_LPF_TimeConstant	Sets or returns the time constant for the low-pass filter applied to the resultant force.

Tmag_LPF_TimeConstant	Sets or returns the time constant for the low-pass filter applied to the resultant torque.
LPF_TimeConstants	Sets or returns the time constant for the low-pass filter applied to each axis simultaneously.
AvgForceClear	Activates/inactivates force and torque averaging simultaneously.
PeakForceClear	Activates/inactivates force and torque peak value calculations simultaneously.
LogEnd	Ends recording of sensor values, robot position/orientation, step data, and the time of data acquisition.
LogStart	Begins recording of sensor values, robot position/orientation, step data, and the time of data acquisition.
FCMEnd	Ends recording of the sensor value, position and orientation of the robot, and StepID using the force control monitor.
FCMStart	Begins recording of the sensor value, position and orientation of the robot, and StepID using the force control monitor.
RecordEnd	Ends recording of sensor values, robot position/orientation, and StepID that starts by RecordStart property.
RecordStart	Begins recording of sensor values, robot position/orientation, StepID, and the time of data acquisition.
Fx_Force	Returns X axis force.
Fy_Force	Returns Y axis force.
Fz_Force	Returns Z axis force.
Tx_Force	Returns X axis torque.
Ty_Force	Returns Y axis torque.
Tz_Force	Returns Z axis torque.
Fmag_Force	Returns the resultant force for the force monitor object.
Tmag_Force	Returns the resultant torque for the force monitor object.
Forces	Returns all force data, torque data, resultant force data, and resultant torque data on force monitor object.
Fx_AvgForce	Returns average Fx force.
Fy_AvgForce	Returns average Fy force.
Fz_AvgForce	Returns average Fz force.
Tx_AvgForce	Returns average Tx torque.
Ty_AvgForce	Returns average Ty torque.
Tz_AvgForce	Returns average Tz torque.
Fmag_AvgForce	Returns average resultant force.
Tmag_AvgForce	Returns average resultant torque.
AvgForces	Returns average force and torque simultaneously.
Fx_PeakForce	Returns the peak Fx force.
Fy_PeakForce	Returns the peak Fy force.
Fz_PeakForce	Returns the peak Fz force.
Tx_PeakForce	Returns the peak Tx torque.
Ty_PeakForce	Returns the peak Ty torque.

Tz_PeakForce	Returns the peak Tz torque.
Fmag_PeakForce	Returns the resultant force peak.
Tmag_PeakForce	Returns the resultant torque peak.
PeakForces	Returns the resultant force and torque peaks simultaneously.

MP (Mass Properties) Object

Comments

This object (collectively) deals with the Mass Property for gravity compensation.

Range

MP0 to MP15

However, MP0 is fixed when the values are such that gravity compensation inactivated. Modification is not possible.

Label	Sets or returns the label.
Number	Returns the number.
Description	Establishes or returns the explanation.
Mass	This sets or returns the weight of the hand and workpiece/payload at the leading end side from the force sensor.
GravityCenter	This sets or returns the overall center of gravity of the hand and workpiece/payload at the leading end side from the force sensor.

Force Guide Sequence Result

Comments

Result of force guide sequence. There are the following types:

EndStatus	Execution result of a force guide sequence.
EndStatusData	Additional information for EndStatus.
Time	Execution time for a force guide sequence.
LastExecObject	Name of the force guide object that was executed at the end.
EndForces	Force and torque at end of a force guide sequence.
PeakForces	Returns the peak values of force and torque during execution of a force guide sequence.

Contact Object Result

Comments

Result of Contact object. There are the following types:

EndStatus	Execution results of the object.
ConditionStatus	Status of end condition achievement.
Time	Execution time for the object.
EndForces	Force and torque at end of the object.
EndPos	Robot position/orientation at end of the object.
AvgForces	Average value of force and torque during object execution.
PeakForces	Peak value of force and torque during object execution.
TriggeredForces	Force and torque when the end conditions of force are achieved.
TriggeredPos	Robot position/orientation when the end conditions of force are achieved.

Relax Object Result

Comments

Result of Relax object. There are the following types:

EndStatus	Execution results of the object.
ConditionStatus	Status of end condition achievement.
Time	Execution time for the object.
EndForces	Force and torque at end of the object.
EndPos	Robot position/orientation at end of the object.
AvgForces	Average value of force and torque during object execution.
PeakForces	Peak value of force and torque during object execution.
TriggeredForces	Force and torque when the end conditions of force are achieved.
TriggeredPos	Robot position/orientation when the end conditions of force are achieved.

FollowMove Object Result

Comments

Result of FollowMove object. There are the following types:

EndStatus	Execution results of the object.
ConditionStatus	Status of end condition achievement.
Time	Execution time for the object.
EndForces	Force and torque at end of the object.
EndPos	Robot position/orientation at end of the object.
AvgForces	Average value of force and torque during object execution
PeakForces	Peak value of force and torque during object execution.

SurfaceAlign Object Result

Comments

Result of SurfaceAlign object. There are the following types:

EndStatus	Execution results of the object.
ConditionStatus	Status of end condition achievement.
Time	Execution time for the object.
EndForces	Force and torque at end of the object.
EndPos	Robot position/orientation at end of the object.
AvgForces	Average value of force and torque during object execution.
PeakForces	Peak value of force and torque during object execution.
TriggeredForces	Force and torque when the end conditions of force are achieved.
TriggeredPos	Robot position/orientation when the end conditions of force are achieved.

PressProbe Object Result

Comments

Result of PressProbe object. There are the following types:

EndStatus	Execution results of the object.
ConditionStatus	Status of end condition achievement.
Time	Execution time for the object.
EndForces	Force and torque at end of the object.
EndPos	Robot position/orientation at end of the object.
AvgForces	Average value of force and torque during object execution.
PeakForces	Peak value of force and torque during object execution.
TriggeredForces	Force and torque when the end conditions of force are achieved.
TriggeredPos	Robot position/orientation when the end conditions of force are achieved.

ContactProbe Object Result

Comments

Result of ContactProbe object. There are the following types:

EndStatus	Execution results of the object.
ConditionStatus	Status of end condition achievement.
Time	Execution time for the object.
EndForces	Force and torque at end of the object.
EndPos	Robot position/orientation at end of the object.
AvgForces	Average value of force and torque during object execution.
PeakForces	Peak value of force and torque during object execution.
TriggeredForces	Force and torque when the end conditions of force are achieved.
TriggeredPos	Robot position/orientation when the end conditions of force are achieved.

Press Object Result

Comments

Result of Press object. There are the following types:

EndStatus	Execution results of the object.
ConditionStatus	Status of end condition achievement.
Time	Execution time for the object.
EndForces	Force and torque at end of the object.
EndPos	Robot position/orientation at end of the object.
AvgForces	Average value of force and torque during object execution.
PeakForces	Peak value of force and torque during object execution.
TriggeredForces	Force and torque when the end conditions of force are achieved.
TriggeredPos	Robot position/orientation when the end conditions of force are achieved.

PressMove Object Result

Comments

Result of PressMove object. There are the following types:

EndStatus	Execution results of the object.
ConditionStatus	Status of end condition achievement.
Time	Execution time for the object.
EndForces	Force and torque at end of the object.
EndPos	Robot position/orientation at end of the object.
AvgForces	Average value of force and torque during object execution.
PeakForces	Peak value of force and torque during object execution.
TriggeredForces	Force and torque when the end conditions of force are achieved.
TriggeredPos	Robot position/orientation when the end conditions of force are achieved.

SPELFunc Object Result

Comments

Result of SPELFunc object. There are the following types:

EndStatus	Execution results of the object.
Time	Execution time for the object.

Object Designation

Application

Force Control Object FC, Force Coordinate System Object FCS, Force Trigger Object FT, Force Monitor Object FM, Force Sensor Object FS, Mass Property Object MP, Robot Object Robot

Comments

This is a formula specifying the object by a statement or function.

Usage

Force Control Object:	**FC#**	**FC(*#*)**	**FC*(Label)***	**FC*((Var))***
Force Coordinate System Object:	**FCS#**	**FCS(*#*)**	**FCS*(Label)***	**FCS*((Var))***
Force Trigger Object:	**FT#**	**FT(*#*)**	**FT*(Label)***	**FT*((Var))***
Force Monitor Object:	**FM#**	**FM(*#*)**	**FM*(Label)***	**FM*((Var))***
Force Sensor Object:	**FS#**	**FS(*#*)**	-	**FS*((Var))***
Mass Property Object:	**MP#**	**MP(*#*)**	**MP*(Label)***	**MP*((Var))***
Robot Object:	**Robot**			

#	An integer 0 or greater
Label	The label assigned to the object
Var	A variable expressed as an integer or real number 0 or greater

Detailed Explanation

In the statement or function, the respective Number #, object label *Label*, and variable *Var* value are specified for the object. The real number is specified by truncating the decimal places to the nearest whole integer.

Usage Example

Program example which specifies an object.

```
Function Test
    Integer Var
    String Var1$, Var2$
    Var = 1
    FSet FC1.Label, "Label1"             ' Establishes object FC1 label.
    FSet FC(1).Description, "comment 1" ' Establishes object FC1 comments.
    FGet FC(Label1).Description, Var1$  ' Refers to object FC1 by its label.
    Print Var1$                          ' Prints “comment 1”.
    FGet FC((Var)).Description, Var2$   ' Refers to object FC1 by the variable.
    Print Var2$                          ' Prints “comment 1” in the same manner.
Fend
```

Force Guide 7.0 Constant

The following constants are established for Force Guide 7.0.
The constants can be used as needed when writing a program.

Tips
In place of the name of the constant, a value can be inserted directly, but it is recommended that the name of the constants be used throughout the program.

Name of Constants	Values	Application
FG_FX FG_FY FG_FZ FG_TX FG_TY FG_TZ FG_FMAG FG_TMAG	0 1 2 3 4 5 6 7	All force objects
FG_X FG_Y FG_Z FG_U FG_V FG_W	0 1 2 3 4 5	[FlangeOffset|GravityDirection |GravityCenter|Position|Orientation], Property
FG_SPRING FG_DAMPER FG_MASS	0 1 2	FC#.(Axis) Property
FG_LIMIT_S FG_LIMIT_R FG_LIMIT_J	0 1 2	FC#.Limit[Accel|Speed]SRJ Property
FG_XYZ FG_XY FG_YZ FG_ZX	0 1 2 3	FT#.Fmag_Axes, Tmag_Axes Property FM#.Fmag_Axes, Tmag_Axes Property
FG_FORCE FG_DIFF	0 1	FT#.TriggerMode Property
FG_OR FG_AND	0 1	FT#.Operator Property
FG_BASE FG_LOCAL FG_TOOL FG_CUSTOM	0 1 2 3	FCS#.Orientation Property
FG_OUT FG_IN	0 1	FT#.(Axis)_Polarity Property
FG_LOWERLEVEL FG_UPPERLEVEL	0 1	FT#.[Fx|Fy|Fz|Tx|Ty|Tz|Fmag|Tmag]_Levels, Property
FG_CRD_SYS FG_LOCAL_NO	0 1	FCS#.Orientation Property
FG_CURRENT_TOOL	-1	FM#.RobotTool Property
FG_RESET_FINE FG_RESET_WAIT_VIBRATION	0 1	FS#.Reset Property
FG_PASSED FG_FAILED FG_NOEXEC FG_ABORTED	0 1 2 3	Sequence.EndStatus Result Sequence.Object.EndStatus Result

NOTE

Use caution as the names of the force sensing constants and the corresponding functions for axial direction and values are different.

Name of Constants	Values	Application
FORCE_XFORCE	1	Force_GetForces Statement
FORCE_YFORCE	2	
FORCE_ZFORCE	3	
FORCE_XTORQUE	4	
FORCE_YTORQUE	5	
FORCE_ZTORQUE	6	

Arc, Arc3 Statement

Comments

Arc moves the robot in a circular interpolation motion in the XY plane with force control active.

Arc3 moves the robot in a circular interpolation motion in 3 dimensions with the force control active.

Usage

Arc Point1, Point2 [*FC#*] [ROT] [CP] [CF] [Till | Find] [!parallel processing!] [SYNC]

Arc3 Point1, Point2 [*FC#*] [ROT] [ECP] [CP] [CF] [Till | Find] [!parallel processing!] [SYNC]

Point1 Specifies the point data defining the through position of the motion.

Point2 Specified the point data defining the target position of the motion.

FC# Specifies the force control object.

CF Continues the force control function. Can be omitted.

Detailed Explanation

By adding a force control object as a parameter to a normal Arc or Arc3, an Arc or Arc3 motion is carried out with the force control function active.

For Arc and Arc3 motion details, refer to the following manual.
EPSON RC+ 7.0 SPEL+ Language Reference
Arc, Arc3

For details on the force control function, refer to *Move Statement*.

Usage Example

This is an example of a simple program which executes an Arc motion with the force control function active.

In this example, the Arc is executed in the X axis direction of the tool coordinate system with the force control function active.

```
Function ForceArcTest
    FSet FCS1.Orientation, FG_TOOL     ' Sets the force coordinate data

    FSet FC1.CoordinateSystem, FCS1    ' Specifies the force coordinate data
    FSet FC1.Fx_Spring, 0              ' Sets the virtual Fx coefficient of elasticity
    FSet FC1.Fx_Damper, 1              ' Sets the virtual Fx coefficient of viscosity
    FSet FC1.Fx_Mass, 10               ' Sets the virtual Fx coefficient of inertia
    FSet FC1.Fx_Enabled, True          ' Sets the Fx force control function to active

    Arc P0,P1 FC1                      ' Executes an Arc motion with the force control
                                       ' function active
Fend
```

Reference

Arc, Arc3, Move, Force Control Object FC#

AvgForceClear Property

Application

Force Monitor Object FM#

Comments

Activates/inactivates force and torque averaging simultaneously.

Immediate Execution

Yes

Usage

FSet *Object*. **AvgForceClear**, *bValueFx, bValueFy, bValueFz, bValueTx, bValueTy, bValueTz [, bValueFmag, bValueTmag]*

Object	Object name or string variable defining object name The object is specified as either of FM (numerical value) or FM (label).
bValueFx	A Boolean value or formula defining the new value of the property
bValueFy	A Boolean value or formula defining the new value of the property
bValueFz	A Boolean value or formula defining the new value of the property
bValueTx	A Boolean value or formula defining the new value of the property
bValueTy	A Boolean value or formula defining the new value of the property
bValueTz	A Boolean value or formula defining the new value of the property
bValueFmag	A Boolean value or formula defining the new value of the property
bValueTmag	A Boolean value or formula defining the new value of the property

Values

bValueFx, bValueFy, bValueFz, bValueTx, bValueTy, bValueTz, bValueFmag, bValueTmag

Name of Constants	Values	Description
False	0	Inactivates the subject axis. (default)
True	–1	Activates the subject axis.

Detailed Explanation

AvgForceClear activates/inactivates force and torque averaging simultaneously.
Be sure to execute AvgForceClear prior to executing AvgForces and XX_AvgForce. Without executing AvgForceClear, “0” is returned.

Usage Example

This is an example of force averaging in the Fx axis.

```
Function CheckAverageForces
    Double AF(7)
    FSet FC1.Enabled, True, False, False, False, False, False
    FSet FC1.TargetForces, 10, 0, 0, 0, 0, 0
    FSet FS1.Reset
    FSet FM1.CoordinateSystem, FCS0
    FSet FM1.AvgForceClear, True, False, False, False, False, False, False,
False
    FCKeep FC1, 10
    FGet FM1.AvgForces, AF()
    Print AF(FG_FX)
Fend
```

Reference

Force Monitor Object FM#

AvgForces Status

Application

Force Monitor Object FM#

Comments

Returns average force and torque simultaneously.

Usage

FGet *Object*.**AvgForces**, *rArray()*

Object Object name or string variable defining object name
The object is specified as either of FM (numerical value) or FM (label).

rArray() The number of elements, which define the property values, is an array of 8 or more real numbers.

Values

rArray()

Element number	Element number constant	Description
0	FG_FX	Acquires the average Fx force.
1	FG_FY	Acquires the average Fy force.
2	FG_FZ	Acquires the average Fz force.
3	FG_TX	Acquires the average Tx torque.
4	FG_TY	Acquires the average Ty torque.
5	FG_TZ	Acquires the average Tz torque.
6	FG_FMAG	Acquires the average resultant force Fmag.
7	FG_TMAG	Acquires the average resultant torque Tmag.

Note: When the number of elements is an array of 6 or 7, the element number returns 0 to 5.

Detailed Explanation

AvgForces returns force and torque averages simultaneously.
Execute AvgForceClear prior to executing AvgForces. Without executing AvgForceClear, 0 is returned.

When the time from executing AvgForceClear to executing AvgForces is short, an error in the average force and torque is generated. Establish a low-pass filter with a time constant of about 5 times between the AvgForceClear and the AvgForces execution.

There is a time limit on AvgForces. Execute AvgForces within 600 seconds of executing AvgForceClear. When AvgForces is executed after 600 seconds has passed, an error is generated.

Usage Example

This is an example of force averaging in the Fx axis.

```
Function CheckAverageForces
    Double AF(7)
    FSet FC1.Enabled, True, False, False, False, False, False
    FSet FC1.TargetForces, 10, 0, 0, 0, 0, 0
    FSet FS1.Reset
    FSet FM1.CoordinateSystem, FCS0
    FSet FM1.AvgForceClear, True, False, False, False, False, False, False,
False
    FCKeep FC1, 10
    FGet FM1.AvgForces, AF()
    Print AF(FG_FX)
Fend
```

Reference

Force Monitor Object FM#

AvgForces Result

Comments

Returns average values of force and torque during execution of a force guide object.

Usage

FGGet *Sequence*.*Object*.**AvgForces**, *rArray()*

Sequence Force guide sequence name or string variable representing force guide sequence name

Object Force guide object name or string variable representing force guide object name.

rArray Real array variable with six or more elements showing returned values

Values

rArray()

Element number	Element number constant	Description
0	FG_FX	Acquires average value of force in Fx direction during execution of a force guide object.
1	FG_FY	Acquires average value of force in Fy direction during execution of a force guide object.
2	FG_FZ	Acquires average value of force in Fz direction during execution of a force guide object.
3	FG_TX	Acquires average value of torque in Tx direction during execution of a force guide object.
4	FG_TY	Acquires average value of torque in Ty direction during execution of a force guide object.
5	FG_TZ	Acquires average value of torque in Tz direction during execution of a force guide object.

Detailed Explanation

Returns average values of force and torque during execution of a force guide object.

If the number of elements in a specified array variable is less than six, returns force and torque in each direction for the defined element numbers. Also, if the number of elements in the array variable exceeds six, returns force and torque in each direction from element number 0 to 5, while making no change to element number 6 and above.

Usage Example

The following is an example of a simple program that acquires a result with FGGet.

```
Function AvgForceTest
     Double dArray(6)

     Motor On

     FGRun Sequence1
     FGGet Sequence1.Contact01.AvgForces, dArray()  ' Acquisition of AvgForces
     Print dArray(FG_FX)

 Fend
```

Reference

FGGet, Contact object, Relax object, FollowMove object, SurfaceAlign object, PressProbe object, ContactProbe object, Press object, PressMove object

BMove Statement

Comments

This executes in the local selected coordinate system an offset linear interpolation motion with the force control active.

Usage

BMove *P#* [*FC#*] [ROT] [CP] [CF] [Till | Find] [!parallel processing!] [SYNC]

P# Specifies the point data to define the amount of movement.

FC# Specifies the force control object.

CF Continues the force control function. Can be omitted.

Detailed Explanation

By adding a force control object as a parameter to a normal BMove command, a BMove motion is carried with the force control function active.

For BMove motion details, refer to the following manual.
EPSON RC+ 7.0 SPEL+ Language Reference
BMove

For details on the force control function, refer to *Move Statement*.

Usage Example

This is a simple program example for executing a BMove motion with the force control function active.

In this example, the BMove motion is executed with the force control function active in the X axis direction of the tool coordinate system.

```
Function ForceBMoveTest
    FSet FCS1.Orientation, FG_TOOL      ' Sets the force coordinate data

    FSet FC1.CoordinateSystem, FCS1     ' Specifies the force coordinate data
    FSet FC1.Fx_Spring, 0               ' Sets virtual Fx coefficient of elasticity
    FSet FC1.Fx_Damper, 1               ' Sets virtual Fx coefficient of viscosity
    FSet FC1.Fx_Mass, 10                ' Sets virtual Fx coefficient of inertia
    FSet FC1.Fx_Enabled, True           ' Sets the Fx force control function to active

    BMove XY(100,0,0,0) FC1             ' Executes the BMove motion with the force
                                        ' control function active
Fend
```

Reference

BMove, Move, Force Control Object FC#

ConditionStatus Result

Comments

Returns status of end condition achievement for a force guide object.

Usage

FGGet *Sequence*.*Object*.**ConditionStatus**, *iVar*

Sequence Force guide sequence name or string variable representing force guide sequence name

Object Force guide object name or string variable representing force guide object name.

iVar Integer variable that shows a returned value

Values

iVar

Bit	Result
0	Status of achievement of force-related end condition
1	Status of achievement of position-related end condition
2	Status of achievement of I/O-related end condition

Bit values

0: Not achieved
1: Achieved

Detailed Explanation

Returns status of end condition achievement for a force guide object.

Force guide objects can use some of force-related, position-related, and I/O-related end conditions. The ConditionStatus result sets the corresponding bit to “1” if a condition is achieved, or “0” if a condition is not achieved. This result is used to branch processing according to which conditions are achieved.

Usage Example

The following is an example of a simple program that acquires a result with FGGet.

```
Function ConditionStatusTest
     Integer iVar

     Motor On
     FGRun Sequence1

     FGGet Sequence1.Press01.ConditionStatus, iVar ' Acquisition of
ConditionStatus
     If (iVar And &H01) <> 0 Then
         ' Processing when force-related condition is achieved
           —
           —
           —
     ElseIf (iVar And &H02) <> 0 Then
         ' Processing when position-related condition is achieve
           —
           —
           —
     EndIf

 Fend
```

Reference

FGGet, Contact object, Relax object, FollowMove object, SurfaceAlign object, PressProbe object, ContactProbe object, Press object, PressMove object

CoordinateSystem Property

Application

Force Control Object FC#, Force Trigger Object FT#, Force Monitor Object FM#

Comments

Returns or sets the force coordinates.

Immediate Execution

No

Usage

FGet *Object*.**CoordinateSystem**, *iVar*

FSet *Object*.**CoordinateSystem**, *FCS#*

Object Object name or string variable defining object name
The object is specified as FC (numerical value), FT (numerical value), FM (numerical value), FC (label), FT (label), or FM (label).

iVar An integer variable defining the value of the property

FCS# Force Coordinate System Object

Specified as FCS(numerical value) or FCS(label).

Values

iVar

	Value
Minimum	0 (default)
Maximum	63

Detailed Explanation

Sets or returns the force coordinates used with the force control function, the force trigger function, and the force monitor function.
The CoordinateSystem default is FCS0. It means the same since FCS0 matches to the leading point setting of the tool at the moment. (You cannot change FCS0 setting. This is a description to help understanding.)

```
FSet FCS0.Position, 0, 0, 0
FSet FCS0.Orientation, FG_TOOL
```

Usage Example

In this example, after setting the origin and coordinate axes for force coordinate 1, force coordinate 1 is set for the Force Monitor Object, and force data is acquired.

```
Function GetForces
    Real myForces(8)
    FSet FCS1.Position, 0, 0, 100
    FSet FCS1.Orientation, FG_TOOL
    FSet FM1.CoordinateSystem, FCS1
    FGet FM1.Forces, myForces()
    Print myForces(FG_FX), myForces(FG_FY), myForces(FG_FZ)
Fend
```

Reference

Force Coordinate System Object FCS#, Force Control Object FC#, Force Trigger Object FT#, Force Monitor Object FM#

CVMove Statement

Comments

This executes a free curve CP motion, defined by the Curve command, with the force control active.

Usage

CVMove File name[*FC#*] [CP] [CF] [Till | Find] [SYNC]

P# Specifies the point data defining the target position of the motion.

FC# Specifies the force control object.

CF Continues the force control function. Can be omitted.

Detailed Explanation

By adding a force control object as a parameter to a CVMove command, a CVMove motion is executed with the force control function active.

For CVMove motion details, refer to the following manual.
EPSON RC+ 7.0 SPEL+ Language Reference
CVMove

For details on the force control function, refer to *Move Statement*.

Usage Example

This is a simple program example to execute a CVMove motion with the force control function active.

In this example, a CVMove motion is executed with the force control function active in the X axis direction of the tool coordinate system.

```
Function ForceCVMoveTest
     FSet FCS1.Orientation, FG_TOOL        ' Sets the force coordinate data

     FSet FC1.CoordinateSystem, FCS1       ' Specifies the force coordinate data
     FSet FC1.Fx_Spring, 0                 ' Sets virtual Fx coefficient of elasticity
     FSet FC1.Fx_Damper, 1                 ' Sets virtual Fx coefficient of viscosity
     FSet FC1.Fx_Mass, 10                  ' Sets virtual Fx coefficient of inertia
     FSet FC1.Fx_Enabled, True             ' Sets the Fx force control function to
active

     curve "mycurve",O,0,4,P(1:7)          ' Sets a free curve
     CVMove "mycurve" FC1                  ' Executes a Move motion with the force
                                           ' control active
Fend
```

Reference

CVMove, Move, Force Control Object FC#

Description Property

Application

Force Control Object FC#, Force Sensor Object FS#, Force Trigger Object FT#, Force Monitor Object FM#, Force Coordinate System Object FCS#, Mass Property Object MP#

Comments

This refers to the explanation for each object, and provides an explanation for objects other than Force Sensor Objects.

Immediate Execution

No

Usage

FGet *Object1*.Description, ***sVar$***

FSet *Object2*.**Description**, *sValue$*

MPGet *MPbject*.**Description**, *sVar$*

MPSet *MPbject*.**Description**, *sValue$*

Object1	Object name or string variable defining object name The object is specified as FC (numerical value), FS (numerical value), FT (numerical value), FM (numerical value), FCS (numerical value), FC (label), FT (label), FM (label), or FCS (label).
Object2	Object name or string variable defining object name The object is specified as FC (numerical value), FT (numerical value), FM (numerical value), FCS (numerical value), FC (label), FT (label), FM (label), or FCS (label).
MPObject	Mass Property Object name or string variable defining the Mass Property Object name. The Mass Property Object is specified as a MP(numerical value) or MP(label).
sVar$	String variable defining the property value
sValue$	String value or formula defining the property value

Values

String

Detailed Explanation

This allows one to refer to the explanation for each object in Descriptions Property as well as establish/modify the explanation. The Force Sensor Object explanation can be referred to, but cannot be established.
The explanation can be freely written using up to 255 characters.

Usage Example

This is an example of establishing an explanation for an object.

```
> FSet FC1.Description, "force 1"
```

Reference

Force Control Object FC#, Force Sensor Object FS#
Force Trigger Object FT#, Force Monitor Object FM#
Force Coordinate System Object FCS#, Mass Property Object MP#

Enabled Property

Application

Force Control Object FC#, Force Trigger Object FT#

Comments

Activates/inactivates the force control function or the force trigger function for each axis at the same time, or returns the status thereof.

Immediate Execution

No

Usage

FGet *Object*.**Enabled**, *bArray()*

FSet *FC#*.**Enabled**, *bValueFx, bValueFy, bValueFz, bValueTx, bValueTy, bValueTz*

FSet *FT#*.**Enabled**, *bValueFx, bValueFy, bValueFz, bValueTx, bValueTy, bValueTz [,bValueFm, bValueTm]*

Object Object name, or string variable defining the object name
The object is specified as FC (numerical value), FT (numerical value), FC (label), or FT (label).

bArray() The number of elements, which define the property values, is an array of 6 or 8 or more real number variables

bValueFx A Boolean value or formula defining the new value of the property

bValueFy A Boolean value or formula defining the new value of the property

bValueFz A Boolean value or formula defining the new value of the property

bValueTx A Boolean value or formula defining the new value of the property

bValueTy A Boolean value or formula defining the new value of the property

bValueTz A Boolean value or formula defining the new value of the property

bValueFm A Boolean value or formula defining the new value of the property

bValueTm A Boolean value or formula defining the new value of the property

Values

bArray() :

Element number	Element number constant	Description
0	FG_FX	Activates/inactivates Fx.
1	FG_FY	Activates/inactivates Fy.
2	FG_FZ	Activates/inactivates Fz.
3	FG_TX	Activates/inactivates Tx.
4	FG_TY	Activates/inactivates Ty.
5	FG_TZ	Activates/inactivates Tz.
6	FG_FMAG	Activates/inactivates Fmag resultant force.
7	FG_TMAG	Activates/inactivates Tmag resultant torque.

Note: When the number of elements is an array of 6 or 7, or for a force control object, the element number returns 0 to 5.

bValueFx, bValueFy, bValueFz, bValueTx, bValueTy, bValueTz, bValueFm, bValueTm

Name of Constants	Values	Description
False	0	Inactivates the subject axis. (default)
True	–1	Activates the subject axis.

Detailed Explanation

Activates/inactivates the force control function or the force trigger function for each axis at the same time, or returns the status thereof.

For SCARA robots (including RS series), the force control cannot be executed with the FC object when Tx or Ty for the Enable property is “True”.

Reference

Force Control Object FC#, Force Trigger Object FT#

EndForces Result

Comments

Returns force and torque at end of a force guide object or force guide sequence.

Usage

FGGet *Sequence*.**EndForces**, *rArray()*

FGGet *Sequence*.*Object*.**EndForces**, *rArray()*

Sequence	Force guide sequence name or string variable representing force guide sequence name
Object	Force guide object name or string variable representing force guide object name. Omitted when a result of a force guide sequence is acquired.
rArray	Real array variable with six or more elements showing returned values

Values

rArray()

Element number	Element number constant	Description
0	FG_FX	Acquires force in Fx direction at end of a force guide sequence or force guide object.
1	FG_FY	Acquires force in Fy direction at end of a force guide sequence or force guide object.
2	FG_FZ	Acquires force in Fz direction at end of a force guide sequence or force guide object.
3	FG_TX	Acquires torque in Tx direction at end of a force guide sequence or force guide object.
4	FG_TY	Acquires torque in Ty direction at end of a force guide sequence or force guide object.
5	FG_TZ	Acquires torque in Tz direction at end of a force guide sequence or force guide object.

Detailed Explanation

Returns force and torque at end of a force guide object or force guide sequence.

If the number of elements in a specified array variable is less than six, returns force and torque in each direction for the defined element numbers. Also, if the number of elements in the array variable exceeds six, returns force and torque in each direction from element number 0 to 5, while making no change to element number 6 and above.

Usage Example

The following is an example of a simple program that acquires a result with FGGet.

```
Function EndForceTest
     Double dArray(6)

     Motor On

     FGRun Sequence1
     FGGet Sequence1.Contact01.EndForces, dArray() '  Acquisition of EndForces
     Print dArray(FG_FX)

 Fend
```

Reference

FGGet, force guide sequence, Contact object, Relax object, FollowMove object, SurfaceAlign object, PressProbe object, ContactProbe object, Press object, PressMove object

EndPos Result

Comments

Returns position at end of a force guide object.

Usage

FGGet *Sequence*.*Object*.**EndPos**, *P#*

Sequence	Force guide sequence name or string variable representing force guide sequence name
Object	Force guide object name or string variable representing force guide object name.
P#	Variable representing a point data

Detailed Explanation

Returns position at end of a force guide object.

Usage Example

The following is an example of a simple program that acquires a result with FGGet.

```
Function EndPosTest

     Motor On

     FGRun Sequence1
     FGGet Sequence1.Contact01.EndPos, P1    ' Acquisition of EndPos
     Print P1

Fend
```

Reference

FGGet, Contact object, Relax object, FollowMove object, SurfaceAlign object, PressProbe object, ContactProbe object, Press object, PressMove object

EndStatus Result

Comments

Returns end status for a force guide sequence or force guide object.

Usage

FGGet *Sequence*.**EndStatus**, *iVar*

FGGet *Sequence*.*Object*.**EndStatus**, *iVar*

Sequence	Force guide sequence name or string variable representing force guide sequence name
Object	Force guide object name or string variable representing force guide object name. Omitted when a result of a force guide sequence is acquired.
iVar	Integer variable that shows a returned value

Values

iVar

Constant name	Value	Description
FG_PASSED	0	Force guide sequence or force guide object succeeded.
FG_FAILED	1	Force guide sequence or force guide object failed.
FG_NOEXEC	2	Force guide sequence or force guide object has not been executed.
FG_ABORTED	3	Force guide sequence or force guide object stopped during execution.

Detailed Explanation

Returns end status for a force guide sequence or force guide object.

Success/fail criteria differ for each force guide sequence and force guide object. For details about the conditions, refer to the following manual:

EPSON RC+ 7.0 option Force Guide 7.0 Software
Force guide sequence*: 4.2.3 Details on results of force guide sequence*
Force guide object*: 4.3 Force Guide Object*

FG_NOEXEC is returned if a force guide sequence has not been executed. FG_NOEXEC is also returned if a force guide object is not executed depending on conditional branch or if a force guide sequence ends midway through because a preceding object failed. FG_ABORTED is returned if the emergency stop button or the <Stop> button on the [Run] window is pressed during execution, or if Stop input is received via remote input.

Usage Example

The following is an example of a simple program that acquires a result with FGGet.

```
Function EndStatusTest
     Integer iVar

     Motor On

     FGRun Sequence1
     FGGet Sequence1.Contact01.EndStatus, iVar      ' Acquisition of EndStatus
     Print iVar

Fend
```

Reference

FGGet, force guide sequence, Contact object, Relax object, FollowMove object, SurfaceAlign object, PressProbe object, ContactProbe object, Press object, PressMove object, SPEL function object

EndStatusData Result

Comments

Returns a reason for end status failure in a force guide sequence.

Usage

FGGet *Sequence*.**EndStatusData**, *iVar*

Sequence Force guide sequence name or string variable representing force guide sequence name

iVar Integer variable that shows a returned value

Values

iVar

Bit	Result
0	Object whose AbortSeqOnFail is True failed.
1	Start position orientation (X, Y, Z, U, V, W) deviated from the specified range.
2	Starting arm orientation (Hand, Elbow, Wrist) differed from the specified arm orientation.

Bit values

0: Not achieved
1: Achieved

Detailed Explanation

Returns a reason for end status failure in a force guide sequence.

AbortSeqOnFail is a property that specifies whether to end or continue a sequence after a force guide object has failed. If the force guide object whose AbortSeqOnFail is True fails, the force guide sequence will also fail.

The start position/orientation (X, Y, Z, U, V, W) is checked when the PosCheckEnabled property is True. The force guide sequence will fail if the sequence starting position/orientation deviates from the point specified by the StartCheckPoint property by an amount that exceeds the value specified by StartPntTolX in the X direction, exceeds the value specified by StartPntTolY in the Y direction, or exceeds the value specified by StartPntTolZ in the Z direction in the coordinate system specified by StartPntTolLocal, or exceeds the angle specified by StartPntTolRot in the direction of rotation. When a failure occurs, the force guide object will not be executed.

The starting arm orientation (Hand, Elbow, Wrist) is checked when the OrientCheckEnabled property is True. The force guide sequence will fail if the sequence starting arm orientation differs from each arm orientation at a point specified by the StartCheckPoint property. In such a case, the force guide object will not be executed.

Usage Example

The following is an example of a simple program that acquires a result with FGGet.

```
Function EndStatusTest
     Integer iVar

     Motor On

     FGRun Sequence1
     FGGet Sequence1.Contact01.EndStatus, iVar      ' Acquisition of EndStatus
     Print iVar

Fend
```

Reference

FGGet, force guide sequence, Contact object, Relax object, FollowMove object, SurfaceAlign object, PressProbe object, ContactProbe object, Press object, PressMove object

FCEnd Statement

Comments

Stops the active force control function.

Usage

FCEnd

Detailed Explanation

This inactivates the currently active force control function by adding a CF parameter to FCKeep or the motion command.

Reference

FCKeep, Force Control Object FC#

FCKeep Statement

Comments

Activates the force control function, and when the specified amount of time has elapsed, a stop is executed.

Usage

FCKeep *FC#* [CF] [Till | Find] [SYNC], *rValue*

FC# Specifies the force control object.

rValue Real number or formula

Detailed Explanation

This does not execute a motion command, but is used when wanting to activate the force control function over a fixed period of time. When wanting to perform push-work using a fixed force over a fixed period of time, after moving the tool using position control to a point just prior to contact, specify the Force Control Object having had the target force set therein, and execute FCKeep.

In addition, when desiring to continue force control for a fixed period of time following the execution of a motion command, which includes force control, add a force control object and a CF parameter to the motion command and execute, then continue on with the execution of the FCKeep.

Usage Example

This example continues activation of the force control function for a period of 30 seconds in accordance to the Force Control Object FC1.

```
> FCKeep FC1, 30
```

In this example, after moving to P1 with the force control active, in accordance with the Force Control Object FC1, the force control function is maintained for a period of 10 seconds.

```
Function main
    Move P1 FC1 CF
    FCKeep FC1, 10
FEnd
```

Reference

Till, FCEnd, FCOn function, Force Control Object FC#

FCMEnd Property

Application

Force Monitor Object FM#

Comments

Ends recording of the sensor value, position and orientation of the robot, and StepID using the force control monitor.
This property is a function for previous version which is before RC+7.4.0 (F/W 7.4.0.0). We recommend using RecordStart property and RecordEnd property.

Immediate Execution

Yes

Usage

FSet *Object*.**FCMEnd**

Object Object name, or string variable defining the object name
The object is specified as either of FM (numerical value) or FM (label).

Detailed Explanation

Recording of the data is started by FCMStart property. This property is used to stop recording the data before the measurement time specified by FCMStart property elapses.

Usage Example

This is an example to start and stop the data recording using Channel 1 of the force control monitor.
The recording starts to acquire the data with intervals of 0.1 seconds for 60 seconds, and then stops after 10 seconds by the FCMEnd property.
In this example, the Wait statement is used to halt the data recording, but it can be replaced by motion commands to record the force in motion and robot position.

```
Function FCMTest
    FSet FM1.ForceSensor, 1
    FSet FM1.FCMEnd
    FSet FM1.FCMStart, 1, 60, 0.1
    Wait 10
    FSet FM1.FCMEnd
Fend
```

Reference

Force Monitor Object FM#

FCMStart Property

Application

Force Monitor Object FM#

Comments

Begins recording of the sensor value, position and orientation of the robot, and StepID using the force control monitor.
This property is a function for previous version which is before RC+7.4.0 (F/W 7.4.0.0). We recommend using RecordStart property and RecordEnd property.

Immediate Execution

Yes

Usage

FSet *Object*.**FCMStart,** *iValueC, rValueD, rValueI*

Object	Object name, or string variable defining the object name The object is specified as either of FM (numerical value) or FM (label).
iValueC	An integer or formula defining the new value of the property
rValueD	A real number or formula defining the new value of the property
rValueI	A real number or formula defining the new value of the property

Values

rValueC (Channel number)

Value	Description
1	Starts recording using the channel 1 of the force control monitor.
2	Starts recording using the channel 2 of the force control monitor.

rValueD (Measurement time unit [sec])

	Value
Minimum	1*
Maximum	600*

Default: none

rValueI (Measurement interval unit: [sec])

	Value
Minimum	0.002*
Maximum	10*

Default: none

* However, “measurement time / measurement interval” should be 30,000 or less.

Detailed Explanation

This property is used to start recording of the sensor value, position and orientation of the robot, and StepID using the force control monitor.

This property is available when the Controller is connected to the force control monitor. Although the channels 1 and 2 can be used at the same time, it is not possible to start the data recording while by specifying the channel number in use.
The product of specified measurement time and interval “measurement time / measurement interval” cannot exceed 30,000. Also, it is not possible to start the data recording by using the same robot and force monitor object in parallel. To start the two data recording in parallel, use different force monitor objects.
In addition, this property cannot be used together with the LogStart property or EPSON RC+GUI force monitor.

The recorded data is saved to a file according to the force control monitor settings.

This property keeps processing until the measurement time ends or FCMEnd is executed property after the task is finished. We recommend that execute FCMEnd property before executing FCMStart property if you want to execute in a row.

Usage Example

This is an example to start and stop the data recording using Channel 1 of the force control monitor.
The recording starts to acquire the data with intervals of 0.1 seconds for 60 seconds.
In this example, the Wait statement is used to halt the data recording, but it can be replaced by motion commands to record the force in motion and robot position.

```
Function FCMTest
    FSet FM1.ForceSensor, 1
    FSet FM1.FCMEnd
    FSet FM1.FCMStart, 1, 60, 0.1
    Wait 60
    FSet FM1.FCMEnd
Fend
```

Reference

Force Monitor Object FM#

FCOn Function

Comments

Determines if the specified robot is executing the force control function.

Usage

FCOn(*RobotNo*)

RobotNo An integer value or formula which specifies the robot number.

Return Values

Number	Constant	Description
0	Off	Force Control Function is inactive
1	On	Force Control Function is active

Detailed Explanation

This identifies whether the specified robot is executing the force control function or not.
“On” will be returned when the force control function is active due to a CF parameter following the completion of a motion command, or when the force control function is active due to FCKeep.

Usage Example

The following displays the activation status of the force control function.

```
Function main
    If FCOn(1) = Off Then
       Print "Force Control is off"
    EndIf
Fend
```

Reference

FCKeep, FCEnd, Force Control Object FC#

FCSMove Statement

Comments

Executes an offset linear interpolation motion in the specified force coordinate system.

Usage

FCSMove P# { FCS# | FC#} [ROT] [CF] [CP] [Till | Find] [!parallel processing!] [SYNC]

P#	Specifies the target position of the motion using point data.
FCS#	Specifies the force coordinate system object.
FC#	Specifies the force control object.
CF	Continues the force control function. Can be omitted.
ROT	Gives priority to the tool orientation modification and establishes the velocity and acceleration of the motion. Can be omitted.
CP	Specifies the path motion. Can be omitted.
Till | Find	Describes the Till or Find formulas. Can be omitted. Till | Find Till Sw(formula) = {On | Off} Find Sw(formula) = {On | Off}
!parallel processing!	A parallel processing statement can be added in order to execute I/O or other commands during the motion. Can be omitted.
SYNC	Reserves a motion command. The robot will not begin moving until the robot begins moving via the SyncRobots.

Detailed Explanation

This executes an offset linear interpolation motion in the specified force coordinate system.

Specify along with the target coordinates either a Force Coordinate System Object or Force Control Object.

If specifying a force coordinate system object, an offset linear interpolation motion will be executed in the specified force coordinate system.

If specifying a Force Control Object, an offset linear interpolation motion will be executed in force coordinate system specified by the Force Control Object. This motion will be executed with the force control active.

The point flag defined by the point data will be ignored, and the current point flag will be maintained. However, on vertical 6 axis robots (including N series), the point flag is automatically changed to decrease the amount of joint movement.

Each established value for SpeedS and AccelS will be used for the FCSMove velocity and acceleration. For the relationship between velocity and acceleration/deceleration, please see the warning: “Use FCSMove with CP.” However, the velocity and acceleration/deceleration when using a qualified ROT parameter will be the established value for SpeedR and AccelR, respectively. In such instances, the values for SpeedS and AccelS are ignored.

Ordinarily, an error occurs when the movement distance is “0” and there is only articulation movement. By adding a qualified ROT parameter and giving priority to the acceleration/deceleration for the tool orientation modification, there is no error and the motion becomes possible. When adding a qualified ROT parameter and there is no orientation modification and the movement distance is not “0,” an error occurs.

Moreover, an error occurs when the orientation modification velocity is too great with respect to the movement distance, or when the specified rotational velocity exceeds the limitations of the Manipulator. In such instances, reduce the specified velocity, or add a qualified ROT parameter and give priority to the acceleration/deceleration of the orientation modification.

By using a Till qualifier, the robot can be decelerated and stopped mid-motion and the FCSMove completed when the Till conditions are met.

By using a Find qualifier, the point data will be stored in FindPos when the Find conditions are met during the motion.

By using !parallel processing!, another process can be executed parallel to the motion.

Warning

Use FCSMove with CP

When using CP parameters, the motion control within the motion command moves to the next statement at the same time as deceleration begins. This is convenient when desiring to link multiple motion commands for a continuous motion at a fixed velocity. Without using CP, FCSMove will find without fail the arm decelerating and stopping at the specified target coordinates.

Usage Example

This is an example of a movement 100 mm in the X axis direction in the force coordinate system 1.

```
> FCSMove XY(100, 0, 0, 0, 0, 0) FCS1
```

Reference

Force Coordinate System Object FCS#, TMove, AccelS, AccelR, SpeedS, SpeedR

FDef Function

Application

Force Control Object FC#, Force Trigger Object FT#, Force Monitor Object FM#, Force Coordinate System Object FCS#

Comments

Identifies whether the specified force object is defined or not.

Usage

FDef*(Object)*

Object Object name or string variable defining the object name

Return Values

“True” if the specified force object is defined, “False” if undefined.

Detailed Explanation

Identifies whether the specified force object is defined or not.

Usage Example

This is an example of when the object is defined.

```
Function main
    If FDef(FC9) Then
       Print "FC9 is defined"
    EndIf
Fend
```

Reference

Force Object FC#, Force Trigger Object FT#, Force Monitor Object FM#, Force Coordinate System Object FCS#

FDel Statement

Application

Force Control Object#, Force Trigger Object FT#, Force Monitor Object FM#, Force Coordinate System Object FCS#

Comments

This deletes the specified force object.

Usage

FDel *Object1 [, Object2]*

Object1 The object name at the beginning of the object data range to be deleted, or a string variable defining the object name

Object2 The object name at the end of the object data range to be deleted, or a string variable defining the object name

Detailed Explanation

This is used to delete any type of specified force object while the program is running. This deletes the object data starting with the start object and ending with the end object established in the parameters. The start object and end object must be the same type of object. In addition, please assign a smaller number to the start object than the end object. No error occurs when the object is not defined.

Usage Example

This is an example of deleting an object.

```
> FDel FC1              ' Deletes Force Control Object1
> FDel FT2, FT10        ' Deletes Force Trigger Object2 through 10
```

Reference

Force Control Object FC#, Force Trigger Object FT#, Force Monitor Object FM#, Force Coordinate System Object FCS#

FExport Statement

Comments

This exports the force file to the specified path.

Usage

FExport *Filename_sValue$, DestPath_sValue$*

FileName_sValue$	A string value defining the specific file you wish to export. The file extension is ".frc". You cannot specify the path.
DestPath_sValue$	A string value defining the destination path and file. The file extension is ".frc".

Detailed Explanation

This makes a copy of the specified force file in the destination folder.

If a file with the same name exists in the folder, it will be overwritten.

The file name must be alphanumeric characters and the underscore character only, and can be up to 255 characters.

Frequent Errors

Specified destination folder does not exist

When the path of *DestPath_sValue$*does not exist, an error is generated.

Specified file is not found

When the path is included in *FileName_sValue$*, an error is generated.

Usage Example

This is an example of exporting a project file to a separate folder.

```
> FExport "myforce.frc", "C:\temp\myforce.frc"
```

Reference

FImport, FLoad, FSave

FGet Statement

Application

Force Object FC#, Force Trigger Object FT#, Force Monitor Object FM#,
Force Coordinate System Object FCS#

Comments

This is used when acquiring the properties or status of a force object.

Usage

FGet *Object.Property, Var*

Object	Object name, or string variable defining the object name
Property	The name of the property for which the value is to be acquired
Var	Variable which expresses the return value. The number and form differ according to the property.

Detailed Explanation

This is used when acquiring the properties or status of a force object.

Usage Example

This is an example of acquiring from a force monitor object and displaying the axial value of force sensor 1 for each axis.

```
Function test

    Real myForces(8)

    FSet FS1.Reset

    FSet FM1.ForceSensor, 1
    FSet FM1.CoordinateSystem, FCS0
    Do
        FGet FM1.Forces, myForces()
        Print myForces(0), myForces(1), myForces(2)
        Wait 1
    Loop
Fend
```

Reference

FSet

FGGet Statement

Comments

Acquires a result of a force guide sequence or force guide object.

Usage

FGGet *Sequence*.*Result*, *Var*

FGGet *Sequence*.*Object*.*Result*, *Var*

Sequence	Force guide sequence name or string variable representing force guide sequence name
Object	Force guide object name or string variable representing force guide object name. Omitted when a result of a force guide sequence is acquired.
Result	Name of result to acquire a value
Var	Variable that shows a returned value The number and types vary according to results.

Detailed Explanation

Acquires a specified result.

If a result other than EndStatus is specified while the target force guide sequence or force guide object has not been executed by FGRun, an error will occur.

Usage Example

The following is an example of a simple program that acquires a result with FGGet.

```
Function FGGetTest
     Integer iResult

     Motor On

     FGRun Sequence1                          ' Execution of a force guide sequence
     FGGet Sequence1.EndStatus, iResult       ' Acquisition of results
     Print iResult

 Fend
```

Reference

FGRun

FGRun Statement

Comments

Executes a force guide sequence.

Usage

FGRun *Sequence*

Sequence Sequence name or string value representing sequence name

Detailed Explanation

Executes a specified force guide sequence. The force guide sequence starts from the position where the FGRun statement was executed. Execute after moving to the assumed start position by the Go statement, Move statement, or other motion commands.

When the specified force guide sequence ends, the program proceeds to the next statement.

To acquire the results of sequences executed by FGRun, use FGGet.

When path motion is enabled by the CP parameter or CP statement, the program waits until the robot stops and then executes a force guide sequence.

When any of the following conditions is fulfilled at the time of execution start, an error occurs.

- The robot specified in the program differs from the robot specified by the RobotNumber property. Specify the correct robot by the Robot statement.
- The robot type specified in the program differs from the robot type specified by the RobotType property. Specify the correct robot by the Robot statement.
- The tool number specified in the program differs from the tool number specified by the RobotTool property. Specify the correct tool number by the Tool statement.
- Motor is in OFF state. Switch to ON state by the Motor statement.
- Force control function is currently being executed. Stop force control by the FCEnd statement.
- Conveyor tracking is currently being executed. Stop conveyor tracking by the Cnv_AbortTrack statement.
- Currently in the torque control mode.
  Disable the torque control mode by the TC statement.

FGRun, when executed, automatically overwrites the following properties; therefore, it cannot be used together with the following properties:

FM object

AvgForceClear property

PeakForceClear property

Usage Example

The following is an example of a simple program that executes FGRun.

In this example, the results are acquired by FGGet after execution.

```
Function FGRunTest
     Integer iResult

     Motor On

     FGRun Sequence1                          ' Execution of a force guide sequence
     FGGet Sequence1.EndStatus, iResult       ' Acquisition of results
     Print iResult

Fend
```

Reference

FGGet

FImport Statement

Comments

This imports a force file into the currently selected robot project.

Usage

FImport *SourcePath_sValue$, Filename_sValue$ [, RobotNo_iValue]*

SourcePath_sValue$	A string value defining the file you wish to import into the current project. The extension is ".frc"
FileName_sValue$	A string value defining a specific file you wish to import into the current project for the current robot. The extension is ".frc" You cannot specify the path.
RobotNo_iValue	This is a real number expression specifying which robot is associated with the force file. Can be omitted. When the robot number is "0," the force file will be imported as a common force file. When omitted, the current robot number is used.

Detailed Explanation

FImport imports a force file into the currently selected project and adds it to the currently selected robot file. The added file can be loaded with the FLoad statement. When a file with the same file name exists on the currently selected robot, it is overwritten.

The file name must be alphanumeric characters and the underscore character only, and can be up to 255 characters.

Frequent Errors

Specified file does not exist
: When *SourcePath_sValue$* does not exist, an error is generated.

Specified file is not found
: An error occurs when the path is included in *FileName_sValue$*.

Specified file is not on current robot
: When a force file from a different robot is specified in *FileName_sValue$*, an error occurs.

Usage Example

This is an example of importing a force file to the currently selected project.

```
> Robot 1
> FImport "C:\temp\myforce.frc", "myforce.frc"
```

Reference

FExport, FSave, Robot

FLabel$ Function

Application

Force Control Object FC#, Force Trigger Object FT#, Force Monitor Object FM#, Force Coordinate System Object FCS#

Comments

Returns the label for all Force Objects and Force Sensor Objects.

Usage

FLabel$(*Object*)

Object Object name, or string variable defining the object name
Specify the object as FC (numerical value), FC (label), FCS (numerical value), FCS (label), FT (numerical value), FT (label), FM (numerical value), or FM (label).

Return Values

String

Detailed Explanation

Returns the label for all force objects and force sensor objects.

Usage Example

This is an example of establishing a label for a force object and displaying it.

```
> FSet FC1.Label, "Label1"
> Print FLabel$(FC1)
Label1
```

Reference

Label Property, Force Control Object FC#, Force Coordinate System Object FCS#, Force Trigger Object FT#, Force Monitor Object FM#

FlangeOffset Property

Application

Robot Object Robot

Comments

This sets or returns the force sensor position and orientation in the Tool 0 (TCP0, J6 flange) coordinate system.

Usage

FGet Robot.FlangOffset, *rArray()*

FSet Robot.FlangOffset, *rValueX, rValueY, rValueZ, rValueU, rValueV, rValueW*

rArray() The maximum number of elements to define the value of the property is an array of 6 or more real number variables

rValueX A real number or formula defining the new value of the property

rValueY A real number or formula defining the new value of the property

rValueZ A real number or formula defining the new value of the property

rValueU A real number or formula defining the new value of the property

rValueV A real number or formula defining the new value of the property

rValueW A real number or formula defining the new value of the property

Values

rArray()

Element number	Element number constant	Description
0	FG_X	Positional X component
1	FG_Y	Positional Y component
2	FG_Z	Positional Z component
3	FG_U	Positional U component
4	FG_V	Positional V component
5	FG_W	Positional W component

rValueX, rValueY, rValueZ

Item	Values
Minimum	–2000
Maximum	2000

rValueU, rValueV, rValueW

Item	Values
Minimum	–360
Maximum	360

(Default)

Robot type	Sensor type	Mount type	(rValueX, rValueY, rValueZ, rValueU, rValueV, rValueW)
C4 series	S250N	Table Top mounting	(0, 0, 5, 0, 0, 0)
		Ceiling mounting	(0, 0, 5, 180, 0, 0)
C8 series	S250L, S250P	Table Top mounting	(0, 0, 5, 0, 0, 0)
		Ceiling mounting	(0, 0, 5, 180, 0, 0)
		Wall mounting	(0, 0, 5, 0, 0, 0)
N2 series	S250H	Table Top mounting	(0, 0, 5, 180, 0, 0)
		Ceiling mounting	(0, 0, 5, 0, 0, 0)
N6 series	SH250LH	Table Top mounting	(0, 0, 0, 0, 0, 0)
		Ceiling mounting	(0, 0, 0, 180, 0, 0)
G3, G6 series	S2503, S2506	All	(0, 0, -22, 180, 0, 180)
G10, G20 series	S25010		(0, 0, -24, 180, 0, 180)
RS series	S2503		(0, 0, -22, 180, 0, 180)

Detailed Explanation

This sets and returns the orientation and position of the center of the force sensor's base plane in the Tool 0 coordinate system.

This is used when the positional relationship between Tool 0 and the force sensor has changed. Since the sensor reading cannot be acquired in the assumed coordinate system if a mistake is made in the setting operation, re-set it accurately and use the force function.

Usage Example

This is an example of setting the positional relationship between Tool 0 of Robot 1 and the force sensor. (10 mm in the Z axis direction)

```
> Robot 1
> FSet Robot.FlangeOffset, 0, 0, 10, 0, 0, 0
```

Reference

Robot Object Robot

FList Statement

Application

Force Control Object FC#, Force Trigger Object FT#, Force Monitor Object FM#, Force Coordinate System Object FCS#

Comments

Displays a list of objects.

Usage

FList *Object1 [, [Object2]]*

Object1 This is the string variable defining the name of the Force Control Object, Force Trigger Object, Force Monitor Object, or Force Coordinate System Object or Object with which the object data range to be listed starts.

Object2 This is the string variable defining the name of the Force Control Object, Force Trigger Object, Force Monitor Object, or Force Coordinate System Object or Object with which the object data range to be listed ends.

Detailed Explanation

The defined object data from the specified start object to the specified end object is displayed in the Command window or Run window.
When "," and the end object are omitted, only the start object is displayed, and when "," is used and the end object is omitted, all objects from the start object on are displayed.

The output format for each line is the same format as for the FSet Statement.

Object.Property, Values

Object Object name

Property Property name

Values The number representing the value and the format are according to the properties

Usage Example

This is an example of listing force object data.

```
> FList FC1
FC1.Label, "LabelFC1"
FC1.CoordinateSystem, FCS0
FC1.Enabled, False, False, False, False, False, False
FC1.Fx, 0, 10, 10
FC1.Fy, 0, 10, 10
FC1.Fz, 0, 10, 10
FC1.Tx, 0, 50, 5000
FC1.Ty, 0, 50, 5000
FC1.Tz, 0, 50, 5000
FC1.TargetForcePriorityMode, False
FC1.TargetForces, 0, 0, 0, 0, 0, 0
FC1.LimitSpeedSRJ, 50, 25, 50
FC1.LimitAccelSRJ, 200, 100, 100
FC1.Description, ""
```

Reference

Force Control Object FC#, Force Trigger Object FT#, Force Monitor Object FM#, Force Coordinate System Object FCS#

FLoad Statement

Application

Force Control Object FC#, Force Trigger Object FT#, Force Monitor Object FM#, Force Coordinate System Object FCS#

Comments

This loads a force file into the robot's force memory area.

Usage

FLoad *FileName_sValue$ [,***Merge***]*

FileName_sValue$	A character strings specifying the name of the file to be loaded into the robot's force memory area.
Merge	Character string to specify that the current force memory area is not to be cleared.

Detailed Explanation

This loads a force file into the robot's force memory area.
The file extension is fixed to ".frc" If the extension is omitted, ".frc" will be added. The specified file is limited to files within the project. You cannot specify the path.
When Merge is not specified, the object currently in the memory area is cleared prior to loading. When Merge is specified, a new force object is added to the current memory area. When the force object to be added already exists, it is overwritten.

Frequent Errors

Cannot specify path
When *FileName_sValue$* includes the path, an error is generated.

Cannot find specified file (file does not exist)
When *FileName_sValue$* cannot be found, an error occurs.

Force file from different robot
When a force file from a different robot is specified in *FileName_sValue$*, an error occurs
In such cases, either add the force file using the project editor, or execute either FSave or Fimport.

Usage Example

This is an example of loading a force file.

```
> FLoad "myforce.frc"
```

Reference

FSave

Fmag_AvgForce Status

Application

Force Monitor Object FM#

Comments

Returns average resultant force.

Usage

FGet Object.**Fmag_AvgForce,** r*Var*

Object Object name, or string variable defining the object name
The object is specified as either of FM (numerical value) or FM (label).

rVar A real number variable defining the value of the property

Detailed Explanation

Fmag_AvgForce returns the average resultant force.

Execute AvgForceClear before executing Fmag_AvgForce. Without executing AvgForceClear, “0” is returned.

If the time between executing AvgForceClear and executing Fmag_AvgForce is short, an error in the force and torque averages will occur. Establish a low-pass filter with a time constant of about 5 times between the AvgForceClear and the Fmag_AvgForce execution.

There is a time limit on Fmag_AvgForce. Execute Fmag_AvgForce within 600 seconds of executing AvgForceClear. When Fmag_AvgForce is executed after 600 seconds has passed, an error is generated.

Usage Example

This is an example of acquiring the average resultant force.

```
Function CheckAverageForce
   Double AF
   FSet FC1.Enabled, True, False, False, False, False, False
   FSet FC1.TargetForces, 10, 0, 0, 0, 0, 0
   FSet FS1.Reset
   FSet FM1.CoordinateSystem, FCS0
   FSet FM1.AvgForceClear, False, False, False, False, False, False, True,
False
   FCKeep FC1, 10
   FGet FM1.Fmag_AvgForce, AF
   Print AF
Fend
```

Reference

Force Monitor Object FM#

Fmag_Axes Property

Application

Force Trigger Object FT#, Force Monitor Object FM#

Comments

Sets or returns the subject axis to acquire the resultant force.

Immediate Execution

No

Usage

FGet *Object*.**Fmag_Axes**, *iVar*

FSet *Object*.**Fmag_Axes**, *iValue*

Object Object name, or string variable defining the object name
The object is specified as FT (numerical value), FM (numerical value), FT(label), or FM(label).

iVar An integer variable defining the value of the property

iValue An integer value or formula defining the new value of the property.

Values

iValue

Name of Constants	Values	Explanation
FG_XYZ	0	The forces in the X, Y, and Z axes are combined. (default) (Fmag = sqrt($Fx^2 + Fy^2 + Fz^2$))
FG_XY	1	The forces in the X and Y-axes are combined. (Fmag = sqrt($Fx^2 + Fy^2$))
FG_YZ	2	The forces in the Y and Z-axes are combined. (Fmag = sqrt($Fy^2 + Fz^2$))
FG_ZX	3	The forces in the Z and X-axes are combined. (Fmag = sqrt($Fx^2 + Fz^2$))

Detailed Explanation

Fmag produces a value representing the combined force from the subject axes from the X, Y, and Z axes.

This property is used when setting or checking the subject axes to obtain the resultant force.

Usage Example

This is an example of setting the subject axes to obtain the resultant force with respect to Force Monitor Object.

```
Function Test_Fmag_Axes
    Integer iVar
    FSet FM1.Fmag_Axes, FG_ZX
    FGet FM1.Fmag_Axes, iVar
    Print iVar
Fend
```

Reference

Force Trigger Object FT#, Force Monitor Object FM#

Fmag_Enabled Property

Application

Force Trigger Object FT#

Comments

Activates/inactivates the trigger based on Fmag resultant force, or returns the status thereof.

Immediate Execution

No

Usage

FGet *Object*.**Fmag_Enabled,** *bVar*

FSet *Object*.**Fmag_Enabled,** *bValue*

Object Object name, or string variable defining the object name
The object is specified as either of FT (numerical value) or FT (label).

bVar A Boolean variable defining the value of the property

bValue A Boolean value or formula defining the new value of the property

Values

bValue

Name of Constants	Values	Explanation
False	0	Inactivates the subject axis. (default)
True	–1	Activates the subject axis.

Detailed Explanation

This activates/inactivates or returns the trigger, which is tripped by the resultant force Fmag.

Reference

Force Trigger Object FT#

Fmag_Force Status

Application

Force Monitor Object FM#

Comments

Returns the resultant force.

Usage

FGet *Object*.**Fmag_Force**, *rVar*

Object Object name or string variable defining object name
The object is specified as either of FM (numerical value) or FM (label).

rVar A real number variable defining the value of the property

Detailed Explanation

Fmag_Force returns the resultant force of the subject axes specified by Fmag_Axes in the force coordinate system specified by CoordinateSystem.

Usage Example

This example obtains the value of the resultant force in the X and Y axes in the specified force coordinate system.

```
Function Test_Fmag_Force
    Real rVar
    FSet FCS1.Position, 0, 0, 100
    FSet FCS1.Orientation, FG_TOOL
    FSet FM1.ForceSensor, 1
    FSet FM1.CoordinateSystem, FCS1
    FSet FM1.Fmag_Axes, FG_XY
    FGet FM1.Fmag_Force, rVar
    Print rVar
Fend
```

Reference

Force Monitor Object FM#

Fmag_Levels Property

Application

Force Trigger Object FT#

Comments

Sets or returns the upper and lower threshold values for resultant force.

Immediate Execution

No

Usage

FGet *Object*.**Fmag_Levels**, *rArray()*

FSet *Object*.**Fmag_Levels**, *rValueL, rValueU*

Object Object name, or string variable defining the object name
The object is specified as either of FT (numerical value) or FT (label).

rArray() The number of elements, which define the property values, is an array of 2 or more real number variables

rValueL A real number or formula defining the value of the new property

rValueU A real number or formula defining the value of the new property

Values

rArray()

Element number	Element number constant
0	FG_ LOWERLEVEL
1	FG_ UPPERLEVEL

rValueL (Unit: [N])

	Values
Minimum	0 (default)
Maximum	1000

rValueU (Unit: [N])

	Values
Minimum	0
Maximum	1000 (default)

Detailed Explanation

Fmag_Levels sets or returns the upper and lower thresholds for resultant force.

rValueL is the lower threshold. rValueU is the upper threshold. Be sure that rValueL < rValueU.

This is used for error checking and task completion conditions.

Usage Example

This is an example of stopping the robot due to an error from being below the lower threshold or above the upper threshold.

```
Function SettingLevels
     FSet FT1.Enabled, False, False, False, False, False, False, True,
False
     FSet FT1.Fmag_Polarity, FG_OUT
     FSet FT1.Fmag_Levels, 0, 50
     Trap 1, FT1 Call ForceError
Fend

Function ForceError
     AbortMotion All
Fend
```

Reference

Force Trigger Object FT#

Fmag_LPF_Enabled Property

Application

Force Trigger Object FT#, Force Monitor Object FM#

Comments

Activates/inactivates or returns the resultant force low-pass filter.

Immediate Execution

No

Usage

FGet *Object*.**Fmag_LPF_Enabled,** *bVar*

FSet *Object*.**Fmag_LPF_Enabled,** *bValue*

Object Object name, or string variable defining the object name
The object is specified as FT (numerical value), FM (numerical value), FT(label), or FM(label).

bVar A Boolean variable defining the value of the property

bValue A Boolean value or formula defining the new value of the property

Values

Name of Constants	Values	Description
False	0	Sets the low-pass filter to inactive. (default)
True	–1	Sets the low-pass filter to active.

Detailed Explanation

This activates/inactivates or returns the status of the low-pass filter for resultant force.

When the low-pass filter is active, signal noise can be reduced, but the following performance for quick signal changes deteriorates.

The low-pass filter is used with AvgForces status, PeakForces status, the Force Trigger Function, and Force Monitor, but is not applied to Forces status.

Usage Example

This is an example of activating the low-pass filter for resultant force and acquiring the force peak data.

```
Function GetPeakForceTest
    Real myPeakForce
    FSet FCS1.Orientation, FG_TOOL
    FSet FM1.CoordinateSystem, FCS1
    FSet FM1.Fmag_Axes, FG_XYZ
    FSet FM1.Fmag_LPF_Enabled, True
    FSet FM1.Fmag_LPF_TimeConstant, 0.02
    FSet FM1.PeakForceClear, True, True, True, True, True, True, True,
True
    Wait 10
    FGet FM1.Fmag_PeakForce, myPeakForce
    Print myPeakForce
Fend
```

Reference

Force Trigger Object FT#, Force Monitor Object FM#,
Fmag_LPF_TimeConstant Property, LPF_Enabled Property

Fmag_LPF_TimeConstant Property

Application

Force Trigger Object FT#, Force Monitor Object FM#

Comments

Sets or returns the time constant for the low-pass filter applied to the resultant force.

Immediate Execution

No

Usage

FGet *Object*.**Fmag_LPF_TimeConstant**, *rVar*

FSet *Object*.**Fmag_LPF_TimeConstant**, *rValue*

Object	Object name, or string variable defining the object name The object is specified as FT (numerical value), FM (numerical value), FT(label), or FM(label).
rVar	A real number variable defining the value of the property
rValue	A real number or formula defining the new value of the property

Values

rValue (Unit: [sec])

	Values
Minimum	0.002
Maximum	5

Default: 0.01

Detailed Explanation

This specifies the time constant for the resultant force low-pass filter.

The low-pass filter time constant is the time it takes to arrive at an input value of $1\text{-}e^{-1}$ (approximately 63.2%) when giving step input.

The signal noise reduction can be enhanced when increasing the time constant, but the following performance for quick signal changes deteriorates.

The low-pass filter is used with AvgForces Status, PeakForces Status, the Force Trigger Function, and Force Monitor, but is not used with Forces Status.

Usage Example

This example sets the low-pass filter for resultant force and acquires the force peak data.

```
Function GetPeakForceTest
   Real myPeakForce
   FSet FCS1.Orientation, FG_TOOL
   FSet FM1.CoordinateSystem, FCS1
   FSet FM1.Fmag_Axes, FG_XYZ
   FSet FM1.Fmag_LPF_Enabled, True
   FSet FM1.Fmag_LPF_TimeConstant, 0.02
   FSet FM1.PeakForceClear, True, True, True, True, True, True, True,
True
   Wait 10
   FGet FM1.Fmag_PeakForce, myPeakForce
   Print myPeakForce
Fend
```

Reference

Force Trigger Object FT#, Force Monitor Object FM#,
Fmag_LPF_Enabled Property, LPF_TimeConstants Property

Fmag_PeakForce Status

Application

Force Monitor Object FM#

Comments

Returns the resultant force peak.

Usage

FGet *Object*.**Fmag_PeakForce**, *rVar*

Object Object name or string variable defining object name
The object is specified as either of FM (numerical value) or FM (label).

rVar A real number variable defining the value of the property

Detailed Explanation

Fmag_PeakForce returns the value of the resultant force peak.
Execute PeakForceClear before executing Fmag_PeakForce.

Usage Example

This example measures the resultant force peak.

```
Function CheckPeakForce
   Double PF
   FSet FC1.Enabled, True, False, False, False, False, False
   FSet FC1.TargetForces, 10, 0, 0, 0, 0, 0
   FSet FS1.Reset
   FSet FM1.CoordinateSystem, FCS0
   FSet FM1.PeakForceClear, False, False, False, False, False, False, True, False
   FCKeep FC1, 10
   FGet FM1.Fmag_PeakForce, PF
   Print PF
Fend
```

Reference

Force Monitor Object FM#

Fmag_Polarity Property

Application

Force Trigger Object FT#

Comments

Sets or returns for resultant force whether the force trigger is activated or inactivated when values correspond to or do not correspond with threshold values.

Immediate Execution

No

Usage

FGet Object.***Fmag_*Polarity**, *iVar*

FSet Object.***Fmag_*Polarity**, *iValue*

Object Object name, or string variable defining the object name
The object is specified as either of FT (numerical value) or FT (label).

iVar An integer variable defining the value of the property

iValue An integer value or formula defining the new value of the property

Values

iValue

Name of Constants	Values	Description
FG_OUT	0	Triggered when value is not within upper and lower thresholds. (default)
FG_IN	1	Triggered when value is within upper and lower thresholds.

Detailed Explanation

Fmag_Polarity returns the status of or sets whether the force trigger is triggered by either the resultant force being within the thresholds or the resultant force being outside of the thresholds.

Usage Example

This example generates an error and stops the robot when the resultant force is above the upper threshold or below the lower threshold.

```
Function SettingPolarity
   FSet FT1.Enabled, False, False, False, False, False, False, True, False
   FSet FT1.Fmag_Polarity, FG_OUT
   FSet FT1.Fmag_Levels, 0, 50
   Trap 1, FT1 Call ForceError
Fend

Function ForceError
   AbortMotion All
Fend
```

Reference

Force Trigger Object FT#

FNumber Function

Application

Force Control Object FC#, Force Trigger Object FT#, Force Monitor Object FM#, Force Coordinate System Object FCS#

Comments

This returns the force object number corresponding to the label of the specified force object.

Usage

FNumber(*Object***)**

Object Object name, or string variable defining the object name
The object is specified as FC (label), FCS (label), FT (label), or FM (label).

Return Values

Integers

Detailed Explanation

This returns the force object number corresponding to the label of the specified force object. An error occurs when there is no corresponding object.

Usage Example

This is an example of establishing a label for a force object, acquiring the number from that label, then displaying it.

```
> FSet FM1.Label, "Label1"
> Print FNumber(FM(Label1))
 1
```

Reference

Number Property, Label Property, Force Control Object FC#, Force Trigger Object FT#, Force Monitor Object FM#, Force Coordinate System Object FCS#

Forces Status

Application

Force Monitor Object FM#

Comments

This returns data on the resultant force.

Usage

FGet *Object*.**Forces**, *rArray()*

Object Object name or string variable defining object name
The object is specified as either of FM (numerical value) or FM (label).

rArray The number of elements, which define the property values, is an array of 8 or more real numbers.

Values

rArray()

Element number	Element number constant
0	FG_FX
1	FG_FY
2	FG_FZ
3	FG_TX
4	FG_TY
5	FG_TZ
6	FG_FMAG
7	FG_TMAG

Detailed Explanation

Forces returns data on the specified force coordinate system specified by CoordinateSystem.

Since this command acquires the current value, it will acquire the value without the application of the low-pass filter. The data reflecting the application of the low-pass filter can be confirmed via Force Monitor or Force Log.

Usage Example

This example establishes force coordinate systems 1 and 2, and acquires the respective resultant force data.

```
Function Test_Forces
   Real rArray1(8), rArray2(8)
   FSet FCS1.Position, 0, 0, 100
   FSet FCS1.Orientation, FG_TOOL
   FSet FCS2.Position, 0, 0, 5
   FSet FCS2.Orientation, FG_LOCAL, 1
   FSet FM1.ForceSensor, 1
   FSet FM1.CoordinateSystem, FCS1
   FGet FM1.Forces, rArray1()
   Print rArray1(FG_FX), rArray1(FG_FY), rArray1(FG_FZ),
rArray1(FG_TX), rArray1(FG_TY), rArray1(FG_TZ), rArray1(FG_FMAG),
rArray1(FG_TMAG)
   FSet FM1.ForceSensor, 1
   FSet FM1.CoordinateSystem, FCS2
   FGet FM1.Forces, rArray2()
   Print rArray2(FG_FX), rArray2(FG_FY), rArray2(FG_FZ),
rArray2(FG_TX), rArray2(FG_TY), rArray2(FG_TZ), rArray2(FG_FMAG),
rArray2(FG_TMAG)
 Fend
```

Reference

Force Monitor Object FM#

ForceSensor Property

Application

Force Trigger Object FT#, Force Monitor Object FM#

Comments

Sets or returns the number of the force sensor in question.

Usage

FGet *Object*.**ForceSensor**, *iVar*

FSet *Object*.**ForceSensor**, *iValue*

Object Object name, or string variable defining the object name
The object is specified as FT (numerical value), FM (numerical value), FT(label), or FM (label).

iVar An integer variable defining the value of the property

iValue An integer value or formula defining the new value of the property.

Values

iValue (Unit: Number)

	Values
Minimum	1 (default)
Maximum	4

Detailed Explanation

This sets the number of the subject force sensor, or when confirming, uses the properties thereof.

Usage Example

This example sets and acquires the number of the force sensor corresponding to FM1.

```
Function Test_ForceSensor
    Integer iVar
    FSet FM1.ForceSensor, 3
    FGet FM1.ForceSensor, iVar
    Print iVar
Fend
```

Reference

Force Trigger Object FT#, Force Monitor Object FM#

FSave Statement

Comments

This saves the force data in the main memory in the current robot file.

Usage

FSave *FileName_sValue$*

FileName_sValue$ The character string specifying the file name in the force data storage destination.

Detailed Explanation

This saves the force data in the main memory in the current robot file.
The extension is fixed to ".frc" If the extension is omitted, ".frc" will be added. The file name must be alphanumeric characters and the underscore character only, and can be up to 255 characters.
You cannot specify the path. If the force data has not already been saved previously, it will be added to the current robot project.

Frequent Errors

The specified file is not the current robot file

When a force file from a different robot is specified in *FileName_sValue$*, an error occurs.

The path is specified in the specified file name

When the path is included in *FileName_sValue$*, an error occurs.
Be sure to specify the file name only.

File name error

An error is generated when a space or invalid character is contained in *FileName_sValue$*.

Usage Example

This example saves the force file.

```
> FSave "myforce.frc"
```

Reference

FLoad

FSet Statement

Application

Force Object FC#, Force Trigger Object FT#, Force Monitor Object FM#, Force Coordinate System Object FCS#

Comments

Used when setting the value of force object properties.

Usage

FSet *Object.Property, Values*

Object	Object name defining the property value
Property	Property name defining the new value
Values	Parameter The number and form differ according to the property.

Detailed Explanation

This is used to set the force object properties and control the force sensor.

The property modifications made via FSet are only made in memory and are not saved to the file. Call up FSave to save the new settings to the file. In addition, when the Controller power is cycled and the unit reboots, or when a project is loaded, the values from the force file are loaded into memory and the modifications not saved to the file will revert to their original value.

Usage Example

This example sets the properties for Force Monitor Object, and acquires and displays the value in each axis for force sensor 1.

```
Function test

    Real myForces(8)

    FSet FS1.Reset

    FSet FM1.ForceSensor, 1
    FSet FM1.CoordinateSystem, FCS0
    Do
        FGet FM1.Forces, myForces()
        Print myForces(0), myForces(1), myForces(2)
        Wait 1
    Loop
Fend
```

Reference

FGet, FSave, ForceObject

Fx, Fy, Fz, Tx, Ty, Tz Property

Application

Force Control Object FC#

Comments

Sets or returns the value of the following coefficients for force control in the specified axis of the force coordinates.

Virtual coefficients of elasticity (Spring)
Virtual coefficients of viscosity (Damper)
Virtual coefficients of inertia (Mass)

Immediate Execution

No

Usage

FGet *Object*.**XX**, *rArray()*

FSet *Object*.**XX**, *rValueS*, *rValueD*, *rValueM*

Object Object name, or string variable defining the object name
The object is specified as either of FC (numerical value) or FC (label).

XX A character string defining the name of the property

rArray() The number of elements defining the value of the property is an array of 3 or more real numbers

rValueS A real number or formula defining the new value of the property

rValueD A real number or formula defining the new value of the property

rValueM A real number or formula defining the new value of the property

Values

XX

Specified Axis	Description
Fx	Specifies translated force in the X axis.
Fy	Specifies translated force in the Y axis.
Fz	Specifies translated force in the Z axis.
Tx	Specifies rotational force in the X axis.
Ty	Specifies rotational force in the Y axis.
Tz	Specifies rotational force in the Z axis.

rArray()

Element number	Element number constant	Description
0	FG_ SPRING	Virtual coefficient of elasticity
1	FG_ DAMPER	Virtual coefficient of viscosity
2	FG_ MASS	Virtual coefficient of inertia

rValueS

Fx, Fy, Fz	Value (Unit: N/mm)
Minimum	0
Maximum	100

Default: 0

Tx, Ty, Tz	Value (Unit: N·mm/deg)
Minimum	0
Maximum	1000000

Default: 0

rValueD

Fx, Fy, Fz	Value (Unit: N/(mm/sec))
Minimum	0.1 (C8 series: 0.5)
Maximum	200

Default: 10

Tx, Ty, Tz	Value (Unit: N·mm/(deg/sec))
Minimum	10
Maximum	1000000

Default: 3000

rValueM

Fx, Fy, Fz	Value (Unit: mN/(mm/sec^2) = kg)
Minimum	0.001
Maximum	1000

Default: 10

Tx, Ty, Tz	Value (Unit: mN·mm/(deg/sec^2))
Minimum	1000
Maximum	10000000

Default: 30000

Detailed Explanation

This sets or returns the value of the virtual coefficients of elasticity, viscosity, and inertia for force control in the specified axes in the established force coordinate system.

The following properties can be set or retrieved with one command.
(XX indicates either of Fx, Fy, Fz, Tx, Ty, or Tz)
XX_Spring property
XX_Damper property
XX_Mass property

rValueS, rValueD, and rValueM set the virtual coefficients of elasticity, viscosity, and inertia, respectively.

Refer to the following manual for details on coefficients.

EPSON RC+ 7.0 Option Force Guide 7.0

Usage Example

This example sets the virtual coefficients of elasticity, viscosity, and inertia for Fz, and carries out a motion with force control active.

```
Function ForceControlTest
    FSet FCS1.Orientation, FG_TOOL
    FSet FC1.CoordinateSystem, FCS1
    FSet FC1.Enabled, False, False, True, False, False, False
    FSet FC1.Fz, 0.01, 4, 5
    Move CurPos +Z(10) FC1
Fend
```

Reference

Force Control Object FC#

Fx_AvgForce, Fy_AvgForce, Fz_AvgForce Status

Application

Force Monitor Object FM#

Comments

This returns the average translated force in the specified axes.

Usage

FGet *Object*.**XX_AvgForce**, *rVar*

Object Object name or string variable defining object name
The object is specified as either of FM (numerical value) or FM (label).

XX A character string defining the name of the property

rVar A real number variable defining the value of the property

Values

XX

Specified Axis	Description
Fx	Specifies translated force in the X axis.
Fy	Specifies translated force in the Y axis.
Fz	Specifies translated force in the Z axis.

Detailed Explanation

XX_AvgForce returns the average translated force in the specified axis.

Before executing XX_AvgForce, execute AvgForceClear. “0” will be returned if AvgForceClear is not executed.

If the time between executing AvgForceClear and executing XX_AvgForce is short, an error in the force and torque averages will occur. Establish a low-pass filter with a time constant of about 5 times between the AvgForceClear and the XX_AvgForce execution.

There is a time limit on XX_AvgForce. Execute XX_AvgForces within 600 seconds of executing AvgForceClear. When XX_AvgForce is executed after 600 seconds has passed, an error is generated.

Usage Example

This is an example of force averaging in the Fx axis.

```
Function CheckAverageForce
   Double AF
   FSet FC1.Enabled, True, False, False, False, False, False
   FSet FC1.TargetForces, 10, 0, 0, 0, 0, 0
   FSet FS1.Reset
   FSet FM1.CoordinateSystem, FCS0
   FSet FM1.AvgForceClear, True, False, False, False, False, False, False,
False
   FCKeep FC1, 10
   FGet FM1.Fx_AvgForce, AF
   Print AF
Fend
```

Reference

Force Monitor Object FM#

Fx_Damper, Fy_Damper, Fz_Damper Property

Application

Force Control Object FC#

Comments

This sets or returns the value of the virtual coefficient of viscosity for force control in the specified axis for the force in the direction of translation.

Immediate Execution

No

Usage

FGet *Object*.**XX_Damper**, *rVar*

FSet *Object*.**XX_Damper**, *rValue*

Object	Object name, or string variable defining the object name The object is specified as either of FC (numerical value) or FC (label).
XX	A character string defining the name of the property
rVar	A real number variable defining the value of the property
rValue	A real number or formula defining the new value of the property

Values

XX

Specified Axis	Description
Fx	Specifies translated force in the X axis.
Fy	Specifies translated force in the Y axis.
Fz	Specifies translated force in the Z axis.

rValue (Unit: [N/(mm/sec)])

	Values
Minimum	0.1
Maximum	200

(C8 series: 0.5)

Default: 10

Detailed Explanation

This sets or returns the value of the virtual coefficient of viscosity for force control in the specified axis of the established force coordinate system.

Refer to the following manual for details on coefficients.

EPSON RC+ 7.0 option Force Guide 7.0

Usage Example

This example sets the virtual coefficients of elasticity, viscosity, and inertia in Fx and carries out a motion with force control active.

```
FSet FCS1.Orientation, FG_TOOL
FSet FC1.CoordinateSystem, FCS1
FSet FC1.Enabled, True, False, False, False, False, False
FSet FC1.Fx_Spring, 0.01
FSet FC1.Fx_Damper, 4
FSet FC1.Fx_Mass, 5
Move CurPos +X(10) FC1
```

Reference

Force Control Object FC#

Fx_Enabled, Fy_Enabled, Fz_Enabled Property

Application

Force Control Object FC#, Force Trigger Object FT#

Comments

Independently activates/inactivates, or returns the force control function or force trigger function of the translational direction.

Immediate Execution

No

Usage

FGet *Object*.**XX_Enabled**, *bVar*

FSet *Object*.**XX_Enabled**, *bValue*

Object Object name, or string variable defining the object name

XX A character string defining the name of the property

bVar A Boolean variable defining the value of the property

bValue A Boolean value or formula defining the new value of the property

Values

XX

Specified Axis	Description
Fx	Specifies translated force in the X axis.
Fy	Specifies translated force in the Y axis.
Fz	Specifies translated force in the Z axis.

bValue

Name of Constants	Values	Description
False	0	Inactivates the subject axis. (default)
True	−1	Activates the subject axis.

Detailed Explanation

Independently activates/inactivates, or returns the force control function or force trigger function of the translational direction.

Usage Example

This example activates the Force Control Object in the X axis.

```
> FSet FC1.Fx_Enabled, True
```

Reference

Force Control Object FC#, Force Trigger Object FT#

Fx_Force, Fy_Force, Fz_Force Status

Application

Force Monitor Object FM#

Comments

This returns force data for the specified axis.

Usage

FGet *Object*.**XX_Force**, *rVar*

Object Object name or string variable defining object name
The object is specified as either of FM (numerical value) or FM (label).

XX A character string defining the name of the property

rVar A real number variable defining the value of the property

Values

XX

Specified Axis	Description
Fx	Specifies translated force in the X axis.
Fy	Specifies translated force in the Y axis.
Fz	Specifies translated force in the Z axis.

Detailed Explanation

Use this property to confirm the force data for the specified axis in the force coordinate system specified by CoordinateSystem.

Usage Example

This example establishes the force coordinate system 1 for the Force Monitor Object, and acquires X axis force data.

```
Function Test_Fx_Force
    Real rVar
    FSet FCS1.Position, 0, 0, 100
    FSet FCS1.Orientation, FG_TOOL
    FSet FM1.ForceSensor, 1
    FSet FM1.CoordinateSystem, FCS1
    FGet FM1.Fx_Force, rVar
    Print rVar
Fend
```

Reference

Force Monitor Object FM#

Fx_Levels, Fy_Levels, Fz_Levels Property

Application

Force Trigger Object FT#

Comments

This sets or returns the value of the lower force threshold and upper force threshold in the direction of translation in the specified axis.

Immediate Execution

No

Usage

FGet *Object.XX*_**Levels**, *rArray()*

FSet *Object.XX*_**Levels**, *rValueL*, *rValueU*

Object Object name, or string variable defining the object name
The object is specified as either of FT (numerical value) or FT (label).

XX A character string defining the name of the property

rArray() The number of elements defining the values of the property is an array of 2 or more real number variables

rValueL A real number or formula defining the new value of the property

rValueU A real number or formula defining the new value of the property

Values

XX

Specified Axis	Description
Fx	Specifies the X axis in the direction of translation.
Fy	Specifies the Y axis in the direction of translation.
Fz	Specifies the Z axis in the direction of translation.

rArray()

Element number	Element number constant
0	FG_ LOWERLEVEL
1	FG_ UPPERLEVEL

rValueL (Unit: [N])

	Values
Minimum	−1000 (default)
Maximum	1000

rValueU (Unit: [N])

	Values
Minimum	−1000
Maximum	1000 (default)

Detailed Explanation

XX_Levels sets or returns the lower and upper force threshold values for the specified axis in the direction of translation.

rValueL is the lower threshold. rValueU is the upper threshold. Be sure that rValueL < rValueU.

This is used for error checking and task completion conditions.

Usage Example

This is an example of stopping the robot due to an error from being below the lower threshold or above the upper threshold in the Fx direction.

```
Function SettingLevels
   FSet FT1.Enabled, True, False, False, False, False, False, False
   FSet FT1.Fx_Polarity, FG_OUT
   FSet FT1.Fx_Levels, -50, 50
   Trap 1, FT1 Call ForceError
Fend

Function ForceError
   AbortMotion All
Fend
```

Reference

Force Trigger Object FT#

Fx_LPF_Enabled, Fy_LPF_Enabled, Fz_LPF_Enabled Property

Application

Force Trigger Object FT#, Force Monitor Object FM#

Comments

This activates/inactivates or returns the status of the low-pass filter for the specified axis for the force in the direction of translation.

Immediate Execution

No

Usage

FGet *Object*.**XX_LPF_Enabled**, *bVar*

FSet *Object*.**XX_LPF_Enabled**, *bValue*

Object Object name, or string variable defining the object name
The object is specified as FT (numerical value), FT (label), FM (numerical value), or FM (label).

XX A character string defining the name of the property

bVar A Boolean variable defining the value of the property

bValue A Boolean value or formula defining the value of the property

Values

XX

Specified Axis	Description
Fx	Specifies the X axis in the direction of translation.
Fy	Specifies the Y axis in the direction of translation.
Fz	Specifies the Z axis in the direction of translation.

bValue

Name of Constants	Values	Description
False	0	Sets the low-pass filter to inactive. (default)
True	−1	Sets the low-pass filter to active.

Detailed Explanation

This activates/inactivates or returns the status of the low-pass filter for the specified axis for the force in the direction of translation.

When the low-pass filter is active, signal noise can be reduced, but the following performance for quick signal changes deteriorates.
The low-pass filter is used with AvgForces status, PeakForces status, the Force Trigger Function, and Force Monitor. It is not applied to Forces status.

Usage Example

This example sets the low pass filter for Fx and acquires the force peak data.

```
Function GetPeakForceTest
    Real myPeakForce
    FSet FCS1.Orientation, FG_TOOL
    FSet FM1.CoordinateSystem, FCS1
    FSet FM1.Fx_LPF_Enabled, True
    FSet FM1.Fx_LPF_TimeConstant, 0.02
    FSet FM1.PeakForceClear, True, True, True, True, True, True
    Wait 10
    FGet FM1.Fx_PeakForce, myPeakForce
    Print myPeakForce
Fend
```

Reference

Force Trigger Object FT#, Force Monitor Object FM#

Fx_LPF_TimeConstant, Fy_LPF_TimeConstant, Fz_LPF_TimeConstant Property

Application

Force Trigger Object FT#, Force Monitor Object FM#

Comments

This sets the time constant or returns the value thereof for the force in the specified axis in the direction of translation.

Immediate Execution

No

Usage

FGet *Object*.**XX_LPF_TimeConstant**, *rVar*

FSet *Object*.**XX_LPF_TimeConstant**, *rValue*

Object Object name, or string variable defining the object name
The object is specified as FT (numerical value), FT (label), FM (numerical value), or FM (label).

XX A character string defining the name of the property

rVar A real number variable defining the value of the property

rValue A real number or formula defining the new value of the property

Values

XX

Specified Axis	Description
Fx	Specifies the X axis in the direction of translation.
Fy	Specifies the Y axis in the direction of translation.
Fz	Specifies the Z axis in the direction of translation.

rValue (Unit: [sec])

	Values
Minimum	0.002
Maximum	5

Default: 0.01

Detailed Explanation

This sets the time constant for the low-pass filter or returns the status thereof for the specified axis in the direction of translation for the force trigger function or force monitor function.

The low-pass filter time constant is the time it takes to arrive at an input value of $1\text{-}e^{-1}$ (approximately 63.2%) when giving step input.

The signal noise reduction can be enhanced when increasing the time constant, but the following performance for quick signal changes deteriorates.

The low-pass filter is used with AvgForces Status, PeakForces Status, the Force Trigger Function, and Force Monitor. It is not used with Forces Status.

Usage Example

This example sets the low pass filter for Fx and acquires the force peak data.

```
Function GetPeakForceTest
    Real myPeakForce
    FSet FCS1.Orientation, FG_TOOL
    FSet FM1.CoordinateSystem, FCS1
    FSet FM1.Fx_LPF_Enabled, True
    FSet FM1.Fx_LPF_TimeConstant, 0.02
    FSet FM1.PeakForceClear, True, True, True, True, True, True
    Wait 10
    FGet FM1.Fx_PeakForce, myPeakForce
    Print myPeakForce
Fend
```

Reference

Force Trigger Object FT#, Force Monitor Object FM#

Fx_Mass, Fy_Mass, Fz_Mass Property

Application

Force Control Object FC#

Comments

This sets or returns the value of the virtual coefficient of inertia for force control in the specified axis of the force in the translational direction.

Immediate Execution

No

Usage

FSet *Object*.**XX_Mass**, *rValue*

FGet *Object*.**XX_Mass**, *rVar*

Object Object name, or string variable defining the object name
The object is specified as either of FC (numerical value) or FC (label).

XX A character string defining the name of the property

rVar A real number variable defining the value of the property

rValue A real number or formula defining the new value of the property

Values

XX

Specified Axis	Description
Fx	Specifies the X axis in the direction of translation.
Fy	Specifies the Y axis in the direction of translation.
Fz	Specifies the Z axis in the direction of translation.

rValue (Unit: [mN/(mm/sec^2) = kg])

	Values
Minimum	0.001
Maximum	1000

Default: 10

Detailed Explanation

This sets or returns the value of the virtual coefficient of inertia for force control in the specified axis of the force in the direction of translation within the established force coordinate system.

Refer to the following manual for details on coefficients.

EPSON RC+ 7.0 option Force Guide 7.0

Usage Example

This example sets the Fx virtual coefficients of elasticity, viscosity, and inertia, and carries out a motion with force control active.

```
Function Test_Mass
     FSet FCS1.Orientation, FG_TOOL
     FSet FC1.CoordinateSystem, FCS1
     FSet FC1.Enabled, True, False, False, False, False, False
     FSet FC1.Fx_Spring, 0.01
     FSet FC1.Fx_Damper, 4
     FSet FC1.Fx_Mass, 5
     Move CurPos +X(10) FC1
Fend
```

Reference

Force Control Object FC#

Fx_PeakForce, Fy_PeakForce, Fz_PeakForce Status

Application

Force Monitor Object FM#

Comments

This returns the value of the peak force for the specified axis in the direction of translation.

Usage

FGet *Object.XX*_**PeakForce**, *rVar*

Object Object name or string variable defining object name
The object is specified as either of FM (numerical value) or FM (label).

XX A character string defining the name of the property

rVar A real number variable defining the value of the property

Values

XX

Specified Axis	Description
Fx	Specifies the X axis in the direction of translation.
Fy	Specifies the Y axis in the direction of translation.
Fz	Specifies the Z axis in the direction of translation.

Detailed Explanation

XX_PeakForce returns the value of the force peak for the specified axis in the direction of translation.

Before executing XX_PeakForce, execute PeakForceClear.

Usage Example

This example returns the value of the peak force in the Fx direction.

```
Function CheckPeakForce
   Double PF
   FSet FC1.Enabled, True, False, False, False, False, False
   FSet FC1.TargetForces, 10, 0, 0, 0, 0, 0
   FSet FS1.Reset
   FSet FM1.CoordinateSystem, FCS0
   FSet FM1.PeakForceClear, True, False, False, False, False, False, False,
False
   FCKeep FC1, 10
   FGet FM1.Fx_PeakForce, PF
   Print PF
Fend
```

Reference

Force Monitor Object FM#

Fx_Polarity, Fy_Polarity, Fz_Polarity Property

Application

Force Trigger Object FT#

Comments

This returns the status of or sets whether the force trigger is triggered by either being within the thresholds or being outside of the thresholds in the specified axis in the direction of translation.

Immediate Execution

No

Usage

FGet Object.*XX*_**Polarity**, *iVar*

FSet Object.*XX*_**Polarity**, *iValue*

Object Object name, or string variable defining the object name
The object is specified as either of FT (numerical value) or FT (label).

XX A character string defining the name of the property

iVar An integer variable defining the value of the property

iValue An integer value or formula defining the new value of the property

Values

XX

Specified Axis	Description
Fx	Specifies the X axis in the direction of translation.
Fy	Specifies the Y axis in the direction of translation.
Fz	Specifies the Z axis in the direction of translation.

iValue

Name of Constants	Values	Description
FG_OUT	0	Triggered when value is not within upper and lower thresholds. (default)
FG_IN	1	Triggered when value is within upper and lower thresholds.

Detailed Explanation

XX_Polarity returns the status of or sets whether the force trigger is triggered by either being within the thresholds or being outside of the thresholds in the specified axis in the direction of translation.

Usage Example

This example generates an error and stops the robot when the force in the Fx direction is above the upper the upper or below the lower threshold.

```
Function SettingPolarity
    FSet FT1.Enabled, True, False, False, False, False, False, False, False
    FSet FT1.Fx_Polarity, FG_OUT
    FSet FT1.Fx_Levels, -50, 50
    Trap 1, FT1 Call ForceError
Fend

Function ForceError
     AbortMotion All
Fend
```

Reference

Force Trigger Object FT#

Fx_Spring, Fy_Spring, Fz_Spring Property

Application

Force Control Object FC#

Comments

This sets or returns the value of the virtual coefficient of elasticity for force control in the specified axis for the force in the direction of translation.

Immediate Execution

No

Usage

FGet *Object*.**XX_Spring**, *rVar*

FSet *Object*.**XX_Spring**, *rValue*

Object	Object name, or string variable defining the object name The object is specified as either of FC (numerical value) or FC (label).
XX	A character string defining the name of the property
rVar	A real number variable defining the value of the property
rValue	A real number or formula defining the new value of the property

Values

XX

Specified Axis	Description
Fx	Specifies the X axis in the direction of translation.
Fy	Specifies the Y axis in the direction of translation.
Fz	Specifies the Z axis in the direction of translation.

rValue (Unit: [N/mm])

	Values
Minimum	0 (default)
Maximum	100

Detailed Explanation

This sets or returns the value of the virtual coefficient of elasticity for force control in the specified axis in the established force coordinate system.

Refer to the following manual for details on coefficients.

EPSON RC+ 7.0 Option Force Guide 7.0

Usage Example

This example sets the virtual coefficients of elasticity, viscosity, and inertia, and carries about a motion with the force control function active.

```
FSet FCS1.Orientation, FG_TOOL
FSet FC1.CoordinateSystem, FCS1
FSet FC1.Enabled, True, False, False, False, False, False
FSet FC1.Fx_Spring, 0.01
FSet FC1.Fx_Damper, 4
FSet FC1.Fx_Mass, 5
Move CurPos +X(10) FC1
```

Reference

Force Control Object FC#

Fx_TargetForce, Fy_TargetForce, Fz_TargetForce, Property

Application

Force Control Object FC#

Comments

This sets or returns the value of the target force in the specified axis in the direction of translation in the established force coordinate system.

Immediate Execution

No

Usage

FGet *Object*.**XX_TargetForce**, *rVar*

FSet *Object*.**XX_TargetForce**, *rValue*

Object Object name, or string variable defining the object name
The object needs to be specified as either of FC (numerical value) or FC (label).

XX A character string defining the name of the property

rVar A real number variable defining the value of the property

rValue A real number or formula defining the new value of the property

Values

XX

Specified Axis	Description
Fx	Specifies the X axis in the direction of translation.
Fy	Specifies the Y axis in the direction of translation.
Fz	Specifies the Z axis in the direction of translation.

rValue (Unit: [N])

	Values
Minimum	The rated negative detection capability of the force sensor
Maximum	The rated positive detection capability of the force sensor

Default: 0

Detailed Explanation

This sets or returns the value of the target force in the specified axis in the direction of translation in the established force coordinate system.

When the force control function is executed with the target force being set to “0”, the robot can operate while following the external force since it moves so that the force becomes “0”.

When using the force control function having set the target force, there are times that the target force is not achieved even after sufficient time. In such instances, activate the TargetForcePriorityMode in order to accurately match the target force. However, when the TargetForcePriorityMode is activated, operation of the robot will not be in accordance with the established values for the virtual coefficients of elasticity, viscosity, and inertia, and the movement may be slowed at times.

Usage Example

This example sets the Fz virtual coefficients of elasticity, viscosity, and inertia, and carries out a motion with the force control function active.

```
FSet FCS1.Orientation, FG_TOOL
FSet FC1.CoordinateSystem, FCS1
FSet FC1.Enabled, False, False, True, False, False, False
FSet FC1.Fz, 0.01, 4, 5
FSet FC1.Fz_TargetForce, 10
FCKeep FC1, 5
```

Reference

Force Control Object FC#

F_DestPos Function

Comments

Returns the final virtual destination position for position control only, without the effects of force control function.

Usage

F_DestPos

Return Values

Returns the final virtual destination position for position control only, without the effects of force control function.

Detailed Explanation

Returns the position control's final virtual destination position.

The position control's final virtual destination position is the virtual final destination position that the original motion command attempted to travel. When the force control function is used, corrections are made according to the force, so this destination position will not be reached. Also, be aware that this function returns the final destination position even immediately after the start of movement; therefore, the position will not be the robot's current position. If, however, the robot is stopped, it will match the current position.

Usage Example

The following is an example to display the position control's command position.

```
Function F_DestPosTest
    Print F_DestPos
Fend
```

Reference

F_RefPos Function

F_FlangeOffset Statement

Application

Robot Object Robot

Comments

This sets or returns the force sensor position and orientation in the Tool 0 (TCP0, J6 flange) coordinate system.

Usage

F_FlangeOffset

F_FlangeOffset *x_rValue, y_rValue, z_rValue, u_rValue, v_rValue, w_rValue*

x_rValue, … A numerical value or formula defining the new value

Detailed Explanation

This sets or returns the position and orientation of the center of the force sensor base in the Tool 0 coordinate system.

This is used when the positional relationship between Tool 0 and the force sensor has changed. Since the sensor reading cannot be acquired in the assumed coordinate system if a mistake is made in the setting operation, set it accurately and use the force function.

Usage Example

This example sets the position of the force sensor flange (10, 10, 10, 5, 5, 10) and confirms the setting results.

```
> F_FlangeOffset 10, 10, 10, 5, 5, 10
> F_FlangeOffset
      10.000,   10.000,   10.000,    5.000,    5.000,   10.000
```

Reference

Robot Object Robot

F_GravityDirection Statement

Application

Robot Object Robot

Comments

This returns the value of or sets, as a vector, the direction of gravity for the Robot Object.

Usage

F_GravityDirection

F_GravityDirection *x_rValue, y_rValue, z_rValue*

x_rValue, … A numerical value or formula defining the new value

Detailed Explanation

This returns the value of or sets the orientation of the gravitational acceleration vector in the base coordinate system.

Since only the direction of gravity is set, it is recommended that the following be reflected in the settings:

rValueX2 + rValueY2 + rValueZ2 = 1

Should the settings of (rValueX, rValueY, rValueZ) = (0, 0, 0), the direction of gravity will not be fixed, so an error will occur.

Usage Example

This example sets the direction of gravity to (10, 10, 10), and confirms the results of the setting.

```
> F_GravityDirection 10, 10, 10
> F_GravityDirection
    10.000,    10.000,    10.000
```

Reference

Robot Object Robot

F_OffsetPos Function

Comments

Returns the position of relative movement from the reference point at a specified distance and angle.

Usage

F_OffsetPos(*Point1, Point2, iValue, iValueL***)**

F_OffsetPos(*Point1, Point2, iValue***)**

F_OffsetPos(*Point1, iValue, iValueL***)**

F_OffsetPos(*Point1, iValue***)**

Point1	Point data/point designation to show amount of relative movement
Point2	Point data/point designation to show reference position. Can be omitted.
iValue	Integer or expression representing coordinate system to perform relative movement
iValueL	Integer or expression representing local coordinate system to perform relative movement. Specified only when local coordinate system is specified for iValue.

Return Values

Returns the position of relative movement from the reference point at a specified distance and angle.

Values

iValue

Constant name	Value	Description
FG_BASE	0	Causes relative movement in the base coordinate system.
FG_LOCAL	1	Causes relative movement in the local coordinate system. Must also specify iValueL.
FG_TOOL	2	Causes relative movement in the tool coordinate system.

iValueL

	Value
Minimum value	0
Maximum value	15

Default: none

Detailed Explanation

Returns the position of relative movement from the reference point at a specified distance and angle.
Since this command is not a movement command, the robot will not move

When FG_BASE is specified for iValue, return a position that is moved the amount of relative movement specified in Point1 based on the direction of base coordinate system.
When FG_LOCAL is specified, return a relative position based on direction of local coordinate system specified in iValueL.
When FG_TOOL is specified, return a relative position based on direction of currently selected tool coordinate system.

Point 1 indicates the amount of relative movement. Only X, Y, Z, U, V, W, S, and T values are referenced, and other flag information such as Hand is not used.

Point 2 indicates the reference position for finding a relative movement position. If Point 2 is omitted, the position control's final virtual destination position which is acquirable with F_DestPos will be returned as the reference position.

An error will occur if the amount of movement is specified for Point 1 with respect to a value not defined for Point 2. For example, if Point 1 is specified as "XY(10,0,0,0,0,0) :ST(10, 10)" and Point 2 as "XY(10,0,0,0,0,0)", S and T values will not be defined for Point 2, but will be defined for Point 1, resulting in an error.

Usage Example

The following is an example to display relative movement positions.

```
Function F_RefPosTest
     Print F_OffsetPostest (P0, P1, FG_BASE)
     Print F_OffsetPostest (XY(10,0,0,0,0,0), P1, FG_BASE)
     ' Position after moving 10 mm from P1 to X direction of base coordinate system
     Print F_OffsetPostest (XY(0,10,0,0,0,0), FG_LOCAL, 1)
     ' Position after moving 10 mm from position control's final virtual destination position to Y
direction
     ' of Local 1 coordinate system
     Print F_OffsetPostest (P0, P1, FG_BASE)

Fend
```

Reference

F_DestPos Function

F_RefPos Function

Comments

Returns the current virtual command position for position control only, without the effects of force control function.

Usage

F_RefPos

Return Values

Returns the current virtual command position for position control only, without the effects of force control function.

Detailed Explanation

Returns the virtual command position for position control. The position is the same as the position that can be acquired by the second variable in the RefPos status.

The position control's virtual command position indicates the virtual trajectory that the original motion command attempted to travel. When the force control function is enabled, the robot will move toward a position that is corrected according to the actual force along the virtual trajectory.

Usage Example

The following is an example to display the position control's command position.

```
Function F_RefPosTest
    Print F_RefPos
Fend
```

Reference

RefPos Status

GetRobotFCOn Function

Comments

This identifies with which robot the force control function is active.

Usage

GetRobotFCOn

Values

Bit	Results
0	Robot 1 status
1	Robot 2 status
2	Robot 3 status
3	Robot 4 status
4	Robot 5 status
5	Robot 6 status
6	Robot 7 status
7	Robot 8 status
8	Robot 9 status
9	Robot 10 status
10	Robot 11 status
11	Robot 12 status
12	Robot 13 status
13	Robot 14 status
14	Robot 15 status
15	Robot 16 status

The value of each Bit

0: Force control function inactive

1: Force control function active

Return Values

This returns the integer value obtained by setting the bits corresponding to the robot numbers for robots with the force control function active to “1”.

Bit 0 represents robot 1, and the subsequent numbers in order represent each of the other robots.

For example, when the force control function is active on robot 1 and robot 3, bit 0 and bit 2 are “On”, so “5” is returned.

The GetRobotFCOn function returns values from 0 to 65535 (hexadecimal FFFF). Because of this, the range of integers can be exceeded. When substituting a value for a variable, use Int32 or Int64 type variables.

Usage Example

This example identifies the robots with the force control function active.

```
Function TestGetRobotFCOn
     Int32 iVar          ' Use Int32 or Int64 type
     Robot 1
     FCKeep FC1 CF, 5    ' Continues the force control function by virtue of the CF parameter
     Print GetRobotFCOn  ' Bit “1” is displayed when Force Control Function is active on robot
1

     iVar = GetRobotFCOn' Save status on variable

     FCKeep FC1, 5       ' Force Control Function is inactive when FCKeep stops
     Print GetRobotFCOn  ' Bit “0” is displayed when Force Control Function is inactive on
robot 1
Fend
```

Reference

FCKeep, FCEnd, Force Control Object FC#

GravityCenter Property

Application

Mass Property Object MP#

Comments

Sets or returns the value of the center of gravity for the overall robot hand and workpiece/payload at the leading end side from the force sensor.

Usage

MPGet *Object*.**GravityCenter**, *rArray()*

MPSet *Object*.**GravityCenter**, *rValueX, rValueY, rValueZ*

Object Object name, or string variable defining the object name
Object is specified as either of MP (numerical value) or MP (label).

rArray() The maximum number of elements to define the value of the property is an array of 3 or more real number variables

rVvalueX A real number or formula defining the new value of the property

rValueY A real number or formula defining the new value of the property

rValueZ A real number or formula defining the new value of the property

Values

rArray()

Element number	Element number constant	Description
0	FG_X	Center of gravity in X direction
1	FG_Y	Center of gravity in Y direction
2	FG_Z	Center of gravity in Z direction

rVvalueX, rValueY, rValueZ (Unit: [mm])

	Values
Minimum	–2000
Maximum	2000

Default: 0

Detailed Explanation

Sets or returns the value of the center of gravity for the overall robot hand and workpiece/payload at the leading end side from the force sensor (not including the force sensor).

Set the position of the center of gravity for the Tool 0 coordinate system (robot hand center datum).

Mass Property Object is used to compensate for the effects of gravity on the force control function.

Usage Example

This example carries out a motion with the force control function active after setting the Mass Property Object.

```
> MPSet MP1.GravityCenter, 10, 10, 100
> MPSet MP1.Mass, 2
> MP 1
> Move CurPos +TLW(10) FC1 ROT
```

Reference

Mass Property Object MP#

GravityDirection Property

Application

Robot Object Robot

Comments

Sets or returns the direction of gravity for the robot.

Usage

FGet Robot.GravityDirection, *rArray()*

FSet Robot.GravityDirection, *rValueX, rValueY, rValueZ*

rArray() The maximum number of elements to define the value of the property is an array of 3 or more real number variables

rValueX A real number or formula defining the new value of the property

rValueY A real number or formula defining the new value of the property

rValueZ A real number or formula defining the new value of the property

Values

rArray()

Element number	Element number constant	Description
0	FG_X	X component of gravitational vector
1	FG_Y	Y component of gravitational vector
2	FG_Z	Z component of gravitational vector

rValueX, rValueY, rValueZ

	Values
Minimum	–1
Maximum	1

Default: (rValueX, rValueY, rValueZ) = (0, 0, -1)

NOTE: Should (rValueX, rValueY, rValueZ) = (0, 0, 0), an error will occur.

Detailed Explanation

This sets or returns the orientation of the vector of gravitational acceleration in the base coordinate system.

Since only the direction of gravity is set, it is recommended that the following be reflected in the settings:

$rValueX^2 + rValueY^2 + rValueZ^2 = 1$

Should the settings of (rValueX, rValueY, rValueZ) = (0, 0, 0), the direction of gravity will not be fixed, so an error will occur.

Usage Example

This example sets the direction of gravity and the Mass Property Object, and carries out a motion with the force control function active.

```
> FSet Robot.GravityDirection, 0, 0, -1
> MPSet MP1.GravityCenter, 10, 10, 100
> MPSet MP1.Mass, 2
> MP 1
> Move CurPos +TLW(10) FC1 ROT
```

Reference

Robot Object Robot

HoldTimeThresh Property

Application

Force trigger object FT#

Comments

Sets or returns the duration used to determine that trigger conditions have been achieved for a force trigger.

Immediate Execution

No

Usage

FGet *Object*.**HoldTimeThresh**, *rVar*

FSet *Object*.**HoldTimeThresh**, *rValue*

Object	Object name or string variable representing object name Object is specified as either of FT (numerical value) or FT (label).
rVar	Real variable that shows a value of property
rValue	Real value or expression that shows new value of property

Values

rValue (units: sec)

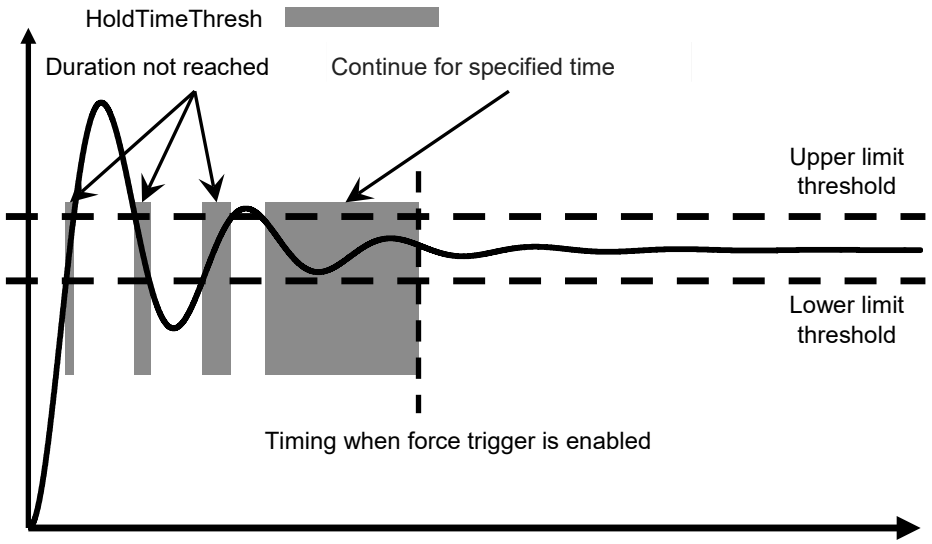
	Value
Minimum value	0
Maximum value	10

Default: 0

Detailed Explanation

This property is used when setting or checking the duration used to determine that trigger conditions have been achieved for a force trigger.

If the conditions specified for a force trigger object continued during the time specified by HoldTimeThresh, the force trigger is enabled. If "0" is specified for HoldTimeThresh, the force trigger will be enabled when the conditions specified for the force trigger object are achieved. Use this property, for instance, when you wish to detect when a force has stabilized or to eliminate the effects of noise and/or vibration.



Usage Example

The following is an example of setting and acquiring HoldTimeThresh.

```
Function Test_HoldTimeThresh
   Integer rVar
   FSet FT1.HoldTimeThresh, 0.1
   FGet FT1.HoldTimeThresh, rVar
   Print rVar
Fend
```

Reference

Force trigger object FT#

Label Property

Application

Force Control Object FC#, Force Coordinate System Object FCS#,
Force Trigger Object FT#, Force Monitor Object FM#, Mass Property Object MP#,
Force Sensor Object FS#

Comments

Refer to each of the ForceObjects and Force Sensor Object labels, and set each of the ForceObject labels.

Immediate Execution

No

Usage

FGet *Object1*.**Label**, *sVar$*

FSet *Object2*.**Label**, *sValue$*

MPGet *Object3*.**Label**, *sVar$*

MPSet *Object3*.**Label**, *sValue$*

Object1	Object name, or string variable defining the object name The object is specified as FC (numerical value), FCS (numerical value), FT (numerical value), FM (numerical value), or FS (numerical value).
Object2	Object name, or string variable defining the object name The object is specified as FC (numerical value), FCS (numerical value), FT (numerical value), or FM (numerical value).
Object3	Object name, or string variable defining the object name The object is specified as MP (numerical value).
sVar$	A string variable defining the value of the property
sValue$	A character string or formula defining the new value of the property

Values

String value

32 single-byte, 16 double-byte alphanumeric characters, Japanese, and the underscore can be used. However, only English letters or Japanese can be used for the first character. Not case sensitive.

Detailed Explanation

This allows one to refer to or set the Force Object Label. The Force Sensor Object label can be referenced. It cannot be set.

There is a difference between this and the setting of other properties and objects. Other properties can be set using a number and label, but Label Property is for number specified objects only.

Reference

Force Control Object FC#, Force Coordinate System Object FCS#,
Force Trigger Object FT#, Force Monitor Object FM#, Mass Property Object MP#,
Force Sensor Object FS#

LastExecObject Result

Comments

Returns the name of the force guide object that was executed at the end for force guide sequence.

Usage

FGGet *Sequence*.**LastExecObject**, *sVar$*

Sequence Force guide sequence name or string variable representing force guide sequence name

sVar$ String variable defining the returned value.

Detailed Explanation

Returns the name of the force guide object that was executed at the end for force guide sequence. When the force guide sequence fails, you can acquire that the program had proceeded to which force guide object.

Usage Example

The following is an example of a simple program that acquires a result with FGGet.

```
Function LastExecObjectTest
     String sVar$
     Motor On

     FGRun Sequence1
     FGGet Sequence1.LastExecObject, sVar$     ' Acquire LastExecObject
     Print sVar$

 Fend
```

Reference

FGGet, Force guide sequence

LimitAccelJ Property

Application

Force Control Object FC#

Comments

Sets or returns the maximum value for joint acceleration during force control.

Immediate Execution

No

Usage

FGet *Object*.**LimitAccelJ**, *rVar*

FSet *Object*.**LimitAccelJ**, *rValue*

Object	Object name, or string variable defining the object name The object is specified as either of FC (numerical value) or FC (label).
rVar	A real number variable defining the value of the property
rValue	A real number or formula defining the new value of the property.

Values

rValue (Unit: [%])

	Values
Minimum	0.1
Maximum	100 (default)

Detailed Explanation

This sets or returns the maximum value for joint acceleration during force control.

The value established for the LimitAccelJ property expresses a ratio with respect to the maximum acceleration.

When the robot, during force control, attempts to accelerate at a rate in excess of the established property value, the acceleration is automatically limited. The limitation is always active during force control.

In LowPower mode during force control, the motion is automatically corrected to the default Accel value when a value in excess of the default Accel value is established in the LimitAccelJ property.

Usage Example

This is an example of a simple motion program using LimitAccelJ.

The Move motion is carried out at an acceleration of 2[mm/sec^2]; when in the course of the motion, a movement accelerating under force control attempts a motion exceeding 5% of the joint velocity, the acceleration is automatically limited by LimitAccelJ, and the motion is carried out at 5% of the established value of acceleration.

```
Function LimitAccelJTest

    FSet FCS1.Orientation, FG_TOOL    ' Specifies the force coordinate data

    FSet FC1.CoordinateSystem, FCS1   ' Specifies the force coordinate data
    FSet FC1.Fx_Spring, 0             ' Sets the virtual Fx coefficient of elasticity
    FSet FC1.Fx_Damper, 1             ' Sets the virtual Fx coefficient of viscosity
    FSet FC1.Fx_Mass, 10              ' Sets the virtual Fx coefficient of inertia
    FSet FC1.Fx_Enabled, True         ' Sets the Fx force control to active

    FSet FC1.LimitAccelJ, 5           ' Sets the maximum joint acceleration to 5%
    AccelS 2                          ' Sets the CP motion acceleration to 2[mm/sec^2]

    Move P0 FC1                       ' A Move motion with force control

Fend
```

Reference

Force Control Object FC#, Accel

LimitAccelR Property

Application

Force Control Object FC#

Comments

Sets or returns the maximum velocity limit for tool orientation change acceleration during force control.

Immediate Execution

No

Usage

FGet *Object*.**LimitAccelR**, *rVar*

FSet *Object*.**LimitAccelR**, *rValue*

Object	Object name, or string variable defining the object name The object is specified as either of FC (numerical value) or FC (label).
rVar	A real number variable defining the value of the property
rValue	A real number or formula defining the value of the new property

Values

rValue (Unit: [deg/sec^2])

	Values
Minimum	0.1
Maximum	5000

Default: 100

Detailed Explanation

This sets or returns the value of the maximum tool orientation acceleration with force control active.

When the robot attempts to accelerate, with force control active, at a rate in excess of the value established in the LimitAcceIR properties, the acceleration is automatically limited. The limitation is always active during force control.

When executing force control in combination with motion commands that is added a qualified ROT parameter, the value must be greater than the acceleration value established for the robot via AccelR.

In LowPower mode, the motion is automatically corrected to the AccelR default value when force control is active and the value set in AccelR is greater than the AccelR default value.

Usage Example

This is a simple example of a motion program using LimitAccelR.

The Move motion is carried out at an acceleration of 2[deg/sec^2], and when in movement, the robot attempts a motion via force control with an acceleration in excess of 5[deg/sec^2], the acceleration is automatically limited to 5[deg/sec^2] via LimitAccelR.

```
Function LimitAccelRTest
    FSet FCS1.Orientation, FG_TOOL     ' Specifies the force coordinate data

    FSet FC1.CoordinateSystem, FCS1    ' Specifies the force coordinate data
    FSet FC1.Fx_Spring, 0              ' Sets the virtual Fx coefficient of elasticity
    FSet FC1.Fx_Damper, 1              ' Sets the virtual Fx coefficient of viscosity
    FSet FC1.Fx_Mass, 10               ' Sets the virtual Fx coefficient of inertia
    FSet FC1.Fx_Enabled, True          ' Sets the Fx force control to active

    FSet FC1.LimitAccelR, 5    ' Sets the maximum tool orientation modification acceleration to
                               ' 5[deg/sec2]
    AccelR 2                   ' Sets the CP motion acceleration to 2[deg/sec2]

    Move P0 FC1 ROT            ' A Move motion with force control

Fend
```

Reference

Force Control Object FC#, AccelR

LimitAccelS Property

Application

Force Control Object FC#

Comments

This sets or returns the value of the maximum of the tool position modification acceleration during force control

Immediate Execution

No

Usage

FGet *Object*.**LimitAccelS**, *rVar*

FSet *Object*.**LimitAccelS**, *rValue*

Object	An object or a string variable defining the name of the object The object is specified as either of FC (numerical value) or FC (label).
rVar	A real number variable defining the value of the property
rValue	A real number or formula defining the value of the new property

Values

rValue (Unit: [mm/sec^2])

Model of Robot	Maximum	Minimum	Default
N2-A450**	5,000	0.1	200
C4-A901**	15,000		
G3, G6, G10, G20, RS3, RS4, C4-A601**, C8, N6	25,000		

Detailed Explanation

This sets or returns the value of the maximum of the tool position modification acceleration during force control.

When the robot attempts to accelerate, with force control active, at a rate in excess of the value established in the LimitAcceIS properties, the acceleration is automatically limited. The limitation is always active during force control.

When executing force control in combination with motion commands that are not added a qualified ROT parameter except FCKeep, the value must be greater than the acceleration value established for the robot via AccelS.

In LowPower mode, the motion is automatically corrected to the AccelS default value when force control is active and the value set in the LimitAccelS property is greater than the AccelS default value.

Usage Example

This is a simple example of a motion program using LimitAccelS.

The Move motion is carried out at an acceleration of 2[mm/sec^2], and when in movement, the robot attempts a motion via force control with an acceleration in excess of 5[mm/sec^2], the acceleration is automatically limited to 5[mm/sec^2] via LimitAccelS.

```
Function LimitAccelSTest
    FSet FCS1.Orientation, FG_TOOL      ' Specifies the force coordinate data

    FSet FC1.CoordinateSystem, FCS1     ' Specifies the force coordinate data
    FSet FC1.Fx_Spring, 0               ' Sets the virtual Fx coefficient of elasticity
    FSet FC1.Fx_Damper, 1               ' Sets the virtual Fx coefficient of viscosity
    FSet FC1.Fx_Mass, 10                ' Sets the virtual Fx coefficient of inertia
    FSet FC1.Fx_Enabled, True           ' Sets the Fx force control to active

    FSet FC1.LimitAccelS, 5             ' Sets the maximum tool position modification acceleration to 5[mm/sec^2]
    AccelS 2                            ' Sets the CP motion acceleration to 2[mm/sec^2]

    Move P0 FC1                         ' A Move motion with force control

Fend
```

Reference

Force Control Object FC#, AccelS

LimitAccelSRJ Property

Application

Force Control Object FC#

Comments

This sets or returns the maximum values of acceleration for joint acceleration, tool position modification, and tool orientation modification during force control.

Immediate Execution

No

Usage

FGet *Object*.**LimitAccelSRJ**, *rArray()*

FSet *Object*.**LimitAccelSRJ**, *rValueS, rValueR, rValueJ*

Object Object name, or string variable defining the object name
The object is specified as either of FC (numerical value) or FC (label).

array() The maximum element number defining the value of the property is an array of 3 or more real number variables

rValueS A real number or formula defining the new value of the property

rValueR A real number or formula defining the new value of the property

rValueJ A real number or formula defining the value of the new property

Values

rArray()

Element number	Element number constant	Description
0	FG_LIMIT_S	Maximum tool position modification acceleration
1	FG_LIMIT_R	Maximum tool orientation modification acceleration
2	FG_LIMIT_J	Maximum joint acceleration

rValueS (Unit: [mm/sec^2])

Model of Robot	Maximum	Minimum	Default
N2-A450**	5,000	0.1	200
C4-A901**	15,000		
G3, G6, G10, G20, RS3, RS4, C4-A601**, C8, N6	25,000		

rValueR (Unit: [deg/sec^2])

	Values
Minimum	0.1
Maximum	5000

Default: 100

rValueJ (Unit: [%])

	Values
Minimum	0.1
Maximum	100 (default)

Detailed Explanation

This sets or returns the maximum values of acceleration for joint acceleration, tool position modification, and tool orientation modification during force control.

For details on each value, refer to *LimitAccelJ Property, LimitAccelR Property, and LimitAccelS Property*.

Reference

Force Control Object FC#, LimitAccelJ Property, LimitAccelR Property, LimitAccelS Property

LimitSpeedJ Property

Application

Force Control Object FC#

Comments

Sets or returns the maximum velocity limit for joint movement during force control.

Immediate Execution

No

Usage

FGet *Object*.**LimitSpeedJ**, *rVar*

FSet *Object*.**LimitSpeedJ**, *rValue*

Object	Object name, or string variable defining the object name The object is specified as either of FC (numerical value) or FC (label).
rVar	A real number variable defining the value of the property
rValue	A real number or formula defining the new value of the property

Values

rValue (Unit: [%])

	Values
Minimum	0.1
Maximum	100

Default: 50

Detailed Explanation

This sets or returns the maximum joint velocity during force control.

The value established in LimitSpeedJ Property expresses a ratio with respect to the maximum velocity.

When, during force control, the robot attempts to move at a velocity in excess of the value established in LimitSpeedJ Property, the velocity is automatically limited. The limitation is always active during force control.

In LowPower mode, with force control active, when the value established in LimitSpeedJ Property is in excess of the Speed Default value, the Speed is automatically adjusted to the Speed default value.

Usage Example

This is an example of a simple motion program using LimitSpeedJ.

The Move motion is carried out at a velocity of 2[mm/sec], and when in motion, when the robot attempts via force control to move in excess of 5% of the joint velocity, the velocity is automatically limited to 5% via LimitSpeedJ.

```
Function LimitSpeedJTest
    FSet FCS1.Orientation, FG_TOOL    ' Sets the force coordinate data

    FSet FC1.CoordinateSystem, FCS1   ' Specifies the force coordinate data
    FSet FC1.Fx_Spring, 0             ' Sets the virtual Fx coefficient of elasticity
    FSet FC1.Fx_Damper, 1             ' Sets the virtual Fx coefficient of viscosity
    FSet FC1.Fx_Mass, 10              ' Sets the virtual Fx coefficient of inertia
    FSet FC1.Fx_Enabled, True         ' Sets the Fx force control to active

    FSet FC1.LimitSpeedJ, 5           ' Maximum joint velocity is set to 5%
    SpeedS 2                          ' Sets the CP motion velocity to 2[mm/sec]

    Move P0 FC1                       ' A Move motion with force control

Fend
```

Reference

Force Control Object FC#, Speed

LimitSpeedR Property

Application

Force Control Object FC#

Comments

Sets or returns the maximum velocity limit for tool orientation change during force control.

Immediate Execution

No

Usage

FGet *Object*.**LimitSpeedR**, r*Var*

FSet *Object*.**LimitSpeedR**, r*Value*

Object	Object name, or string variable defining the object name The object is specified as either of FC (numerical value) or FC (label).
rVar	A real number variable defining the value of the property
rValue	A real number or formula defining the new value of the property

Values

rValue (Unit: [deg/sec])

	Values
Minimum	0.1
Maximum	1000

Default: 25

Detailed Explanation

Sets or returns the maximum tool orientation modification velocity during force control.

When the robot, during force control, attempts to move at a velocity in excess of the value established in LimitSpeedR properties, the velocity is automatically limited. The limitation is always active during force control.

When executing force control in combination with motion commands that is added a qualified ROT parameter, the value must be greater than the robot speed set by SpeedR.

In LowPower mode, when the value set in LimitSpeedR is greater than the SpeedR default value the motion is automatically adjusted to the SpeedR default value when force control is active.

Usage Example

This is an example of a simple movement program using LimitSpeedR.

The Move motion is carried out at a velocity of 2[deg/sec], and when in motion, the robot attempts to move via force control at a rate in excess of 5[deg/sec], the velocity is automatically limited via LimitSpeedR and carried out at 5[deg/sec].

```
Function LimitSpeedRTest
     FSet FCS1.Orientation, FG_TOOL   ' Sets the force coordinate data

     FSet FC1.CoordinateSystem, FCS1  ' Specifies the force coordinate data
     FSet FC1.Fx_Spring, 0            ' Sets the virtual Fx coefficient of elasticity
     FSet FC1.Fx_Damper, 1            ' Sets the virtual Fx coefficient of viscosity
     FSet FC1.Fx_Mass, 10             ' Sets the virtual Fx coefficient of inertia
     FSet FC1.Fx_Enabled, True        ' Sets the Fx force control to active
     FSet FC1.LimitSpeedR, 5          ' Sets the maximum tool orientation modification velocity to
                                        5[deg/sec]
     SpeedR 2                         ' Sets the CP motion velocity to 2[deg/sec]

     Move P0 FC1 ROT                  ' A Move motion with force control

Fend
```

Reference

Force Control Object FC#, SpeedR

LimitSpeedS Property

Application

Force Control Object FC#

Comments

This sets or returns the maximum tool position modification velocity during force control.

Immediate Execution

No

Usage

FGet *Object*.**LimitSpeedS**, r*Var*

FSet *Object*.**LimitSpeedS**, r*Value*

Object	Object name, or string variable defining the object name The object needs to be specified as either of FC (numerical value) or FC (label).
rVar	A real number variable defining the value of the property
rValue	A real number or formula defining the new value of the property

Values

rValue (Unit: [mm/sec])

	Values
Minimum	0.1
Maximum	2000

Default: 50

Detailed Explanation

This sets or returns the maximum tool position modification velocity during force control.

During force control, when the robot attempts to move at a velocity in excess of that set in LimitSpeedS property, the velocity is automatically limited. The limitation is always active during force control.

When executing force control in combination with motion commands that are not added a qualified ROT parameter except FCKeep, the value must be greater than the robot speed set by SpeedS.

In LowPower mode, when the value set in LimitSpeedS is greater than the SpeedS default value the movement is automatically adjusted to the SpeedS default value when force control is active.

Usage Example

This is a simple example of a motion program using LimitSpeedS.

The Move motion is carried out at a velocity of 2[mm/sec], and when in motion, when the robot attempts via force control to move in excess of 5[mm/sec], the velocity is automatically limited to 5[mm/sec] via LimitSpeedS.

```
Function LimitSpeedSTest
    FSet FCS1.Orientation, FG_TOOL     ' Sets force coordinate data

    FSet FC1.CoordinateSystem, FCS1    ' Specifies the force coordinate data
    FSet FC1.Fx_Spring, 0      ' Sets the virtual Fx coefficient of elasticity
    FSet FC1.Fx_Damper, 1      ' Sets the virtual Fx coefficient of viscosity
    FSet FC1.Fx_Mass, 10       ' Sets the virtual Fx coefficient of inertia
    FSet FC1.Fx_Enabled, True ' Sets the Fx force control to active
    FSet FC1.LimitSpeedS, 5    ' Sets the maximum tool position modification velocity to
5[mm/sec]
    SpeedS 2                   ' Sets the CP motion velocity to 2[mm/sec]

    Move P0 FC1                ' A Move motion with force control

Fend
```

Reference

Force Control Object FC#, SpeedS

LimitSpeedSRJ Property

Application

Force Control Object FC#

Comments

Sets or returns the maximum values of joint velocity, tool position modification velocity, and tool orientation modification velocity with force control active.

Immediate Execution

No

Usage

FGet *Object*.**LimitSpeedSRJ**, *rArray()*

FSet *Object*.**LimitSpeedSRJ**, *rValueS, rValueR, rValueJ*

Object Object name, or string variable defining the object name
The object is specified as either of FC (numerical value) or FC (label).

rArray() The maximum element number defining the value of the property is an array of 3 or more real number variables

rValueS A real number or formula defining the new value of the property

rValueR A real number or formula defining the new value of the property

rValueJ A real number or formula defining the new value of the property

Values

rArray()

Element number	Element number constant	Description
0	FG_LIMIT_S	Maximum tool position modification velocity
1	FG_LIMIT_R	Maximum tool orientation modification velocity
2	FG_LIMIT_J	Maximum joint velocity

rValueS (Unit: [mm/sec])

	Values
Minimum	0.1
Maximum	2000

Default: 50

rValueR (Unit: [deg/sec])

	Values
Minimum	0.1
Maximum	1000

Default: 25

rValueJ (Unit: [%])

	Values
Minimum	0.1
Maximum	100

Default: 50

Detailed Explanation

Sets or returns the maximum values of joint velocity, tool position modification velocity, and tool orientation modification velocity with force control active.

For details on each value, refer to *LimitSpeedJ Property, LimitSpeedR Property,* and *LimitSpeedS Property*.

Reference

Force Control Object FC#, LimitSpeedJ Property, LimitSpeedR Property, LimitSpeedS Property

LogEnd Property

Application

Force Monitor Object FM#

Comments

Ends recording of sensor values, robot position/orientation, step data, and the time of data acquisition.

This property is a function for previous version which is before RC+7.4.0 (F/W 7.4.0.0). We recommend using RecordStart property and RecordEnd property.

Immediate Execution

Yes

Usage

FSet *Object*.**LogEnd**

Object Object name or string variable defining object name
The object is specified as either of FM (numerical value) or FM (label).

Detailed Explanation

This property is used to stop logging the sensor values, robot position and orientation, step data, and acquisition timing.

Usage Example

This is an example of starting the logging of data for sensor 1 (at a frequency of 100 msec for 1 minute) and then ending the logging thereof.

```
Function Test_Log
     Integer iFileNum
     iFileNum = FreeFile
     WOpen "Forcelog.csv" As #iFileNum
     FSet FM1.ForceSensor, 1
     FSet FM1.LogStart, 60, 0.1, #iFileNum
        …
     FSet FM1.LogEnd
     Close #iFileNUm
Fend
```

Reference

Force Monitor Object FM#

LogStart Property

Application

Force Monitor Object FM#

Comments

Begins recording of sensor values, robot position/orientation, step data, and the time of data acquisition.

This property is a function for previous version which is before RC+7.4.0 (F/W 7.4.0.0). We recommend using RecordStart property and RecordEnd property.

Immediate Execution

Yes

Usage

FSet *Object*.**LogStart,** *rValueD, rValueI ,#iValueF*

Object	Object name or string variable defining object name The object is specified as either of FM (numerical value) or FM (label).
rValueD	A real number or formula defining the new value of the property
rValueI	A real number or formula defining the new value of the property
#iValueF	An integer or formula defining the new value of the property

Values

rValueD (Measurement time unit: [sec])

	Values
Minimum	0.01
Maximum	60

Default: None

rValueI (Measurement interval unit: [sec])

	Values
Minimum	0.006
Maximum	10

Default: None

#iValueF (File no.)

	Values
Minimum	30
Maximum	63

Default: None

Detailed Explanation

This property is used to start the logging of sensor values, robot position and orientation, StepID, and measurement timing.

File format:

SequentPeriodic, measurement start time, duration of the measurement, measurement interval, serial code of the Force Sensor, Force Sensor label, Force Monitor object number, Force coordinate object number

ElapsedTime[sec], Force(Fx), Force(Fy), Force(Fz), Torque(Tx), Torque(Ty), Torque(Tz),CurPos(X), CurPos(Y), CurPos(Z),CurPos(U), CurPos(V), CurPos(W), RefPos(X), RefPos(Y), RefPos(Z), DiffAngle(X), DiffAngle(Y), DiffAngle(Z), StepID, Time

(After displaying the above, the actual values will be displayed subsequently.)

Item	Unit	Description
Measurement start time	-	Time when the measurement is started. Displayed in a format of "yyyy/mm/dd hh:mm:ss:ms"
Duration of measurement	sec	Measurement time specified to the LogStart property.
Measurement interval	sec	Measurement interval specified to the LogStart property.
Serial code of the Force Sensor	-	Serial code of the Force Sensor.
Force Sensor label	-	Label set to the Force Sensor.
Force monitor object number	-	Number for the specified Force Monitor object.
Force coordinate object number	-	Number for the specified Force coordinate object.
Force(Fx) to (Fz) Torque(Tx) to (Tz)	N N·mm	Sensor value of each axis in the Force coordinates.
CurPos(X) to (Z)	mm	Command position reflecting the position control-command position and the effects of force control.
RefPos(X) to (Z)	mm	Command-position which reflects only the position control.
DiffAngle(X) to (Z)	deg	Difference between a direction of command reflecting the position control-command position and the effects of force control, and a direction of command which reflects only the position control. The difference is calculated from angle between the axes.
StepID	-	Value specified to the StepID property.
Time	-	Time when the data is measured. Displayed in a format of "yyyy/mm/dd hh:mm:ss: ms".

Usage Example

This is an example of starting the logging of data for sensor 1 (at a frequency of 100 msec for 1 minute) and then ending the logging thereof.

```
Function Test_Log
    Integer iFileNum
    iFileNum = FreeFile
    WOpen "Forcelog.csv" As #iFileNum
    FSet FM1.ForceSensor, 1
    FSet FM1.LogStart, 60, 0.1, #iFileNum
      …
    FSet FM1.LogEnd
    Close #iFileNUm
Fend
```

Following is an example of acquired data.

SequentPeriodic, 2000/01/01 01:02:03:004, 60.000000, 0.100000, AAAAA00001, Sensor1Label, FM0, FCS0

ElapsedTime[sec], Force(Fx), Force(Fy), Force(Fz), Torque(Tx), Torque(Ty), Torque(Tz),CurPos(X), CurPos(Y), CurPos(Z),CurPos(U), CurPos(V), CurPos(W), RefPos(X), RefPos(Y), RefPos(Z), DiffAngle(X), DiffAngle(Y), DiffAngle(Z), StepID,Time

0.100, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 565.000, 720.000, 0.000, -90.000, -90.000, 0.000, 565.000, 720.000, 0.000, 0.000, 0.000, 0, 2000/01/01 01:02:03:004

(After displaying the above, the actual values will be displayed subsequently.)

Reference

Force Monitor Object FM#

LowerLevels Property

Application

Force Trigger Object FT#

Comments

This sets or returns the lower threshold value of force and torque in each axis at the same time.

Immediate Execution

No

Usage

FGet *Object*.**LowerLevels**, *rArray()*

FSet *Object*.**LowerLevels**, *rValueFx, rValueFy, rValueFz, rValueTx, rValueTy, rValueTz [, rValueFmag, rValueTmag]*

Object Object name, or string variable defining the object name
The Object needs to be specified as either of FT (numerical value) or FT (label).

rArray() The maximum number of elements defining the value of the property is an array of 8 or more real number variable

rValueFx A real number or formula defining the new value of the property.

rValueFy A real number or formula defining the new value of the property.

rValueFz A real number or formula defining the new value of the property.

rValueTx A real number or formula defining the new value of the property.

rValueTy A real number or formula defining the new value of the property.

rValueTz A real number or formula defining the new value of the property.

rValueFmag A real number or formula defining the new value of the property.

rValueTmag A real number or formula defining the new value of the property.

Values

rArray()

Element number	Element number constant	Description
0	FG_FX	Acquires the lower threshold value for Fx force.
1	FG_FY	Acquires the lower threshold value for Fy force.
2	FG_FZ	Acquires the lower threshold value for Fz force.
3	FG_TX	Acquires the lower threshold value for Tx torque.
4	FG_TY	Acquires the lower threshold value for Ty torque.
5	FG_TZ	Acquires the lower threshold value for Tz torque.
6	FG_FMAG	Acquires the lower threshold value for Fmag resultant force.
7	FG_TMAG	Acquires the lower threshold value for Tmag resultant torque.

Note: When the number of elements is an array of 6 or 7, this will acquire element numbers 0 to 5.

rValueFx, rValueFy, rValueFz (Unit: [N])

	Values
Minimum	−1000 (default)
Maximum	1000

rValueTx, rValueTy, rValueTz (Unit: [N·mm])

	Values
Minimum	−100000 (default)
Maximum	100000

rValueFmag (Unit: [N])

	Values
Minimum	0 (default)
Maximum	1000

rValueTmag (Unit: [N·mm])

	Values
Minimum	0 (default)
Maximum	100000

Detailed Explanation

LowerLevels sets or returns the lower threshold value for force and torque in each axis.

Be sure that LowerLevels < UpperLevels.

Since all force and torque lower threshold values for each axis are set at one time, it can be done with fewer lines than setting them one axis at a time.

This is used for error checking and task completion conditions.

Usage Example

This example generates an error and stops the robot if force is less than the lower threshold value.

```
Function SettingLevels
    FSet FT1.Enabled, True, True, True, True, True, True, True, True
    FSet FT1.Polarities, FG_OUT, FG_OUT, FG_OUT, FG_OUT, FG_OUT,
FG_OUT, FG_OUT, FG_OUT
    FSet FT1.LowerLevels, -50, -50, -50, -3000, -3000, -3000, 0, 0
    Trap 1, FT1 Call ForceError
Fend

Function ForceError
     AbortMotion All
Fend
```

Reference

Force Trigger Object FT#

LPF_Enabled Property

Application

Force Trigger Object FT#, Force Monitor Object FM#

Comments

This activates/inactivates or returns the status of the low-pass filter in each axis of the force coordinate system.

Immediate Execution

No

Usage

FGet *Object*.**LPF_Enabled**, *bArray()*

FSet *Object*.**LPF_Enabled**, *bValueFx, bValueFy, bValueFz, bValueTx, bValueTy, bValueTz [,bValueFmag, bValueTmag]*

Object	Object name, or string variable defining the object name The object is specified as FT (numerical value), FT (label), FM (numerical value), or FM (label).
bArray()	The maximum number of elements defining the value of the property is an array of 6 or more Boolean variables
bValueFx	A Boolean value or formula defining the new value of the property
bValueFy	A Boolean value or formula defining the new value of the property
bValueFz	A Boolean value or formula defining the new value of the property
bValueTx	A Boolean value or formula defining the new value of the property
bValueTy	A Boolean value or formula defining the new value of the property
bValueTz	A Boolean value or formula defining the new value of the property
bValueFmag	A Boolean value or formula defining the new value of the property
bValueFmag	A Boolean value or formula defining the new value of the property

Values

bArray():

Element number	Element number constant	Description
0	FG_FX	Activates/inactivates the Fx low-pass filter.
1	FG_FY	Activates/inactivates the Fy low-pass filter.
2	FG_FZ	Activates/inactivates the Fz low-pass filter.
3	FG_TX	Activates/inactivates the Tx low-pass filter.
4	FG_TY	Activates/inactivates the Ty low-pass filter.
5	FG_TZ	Activates/inactivates the Tz low-pass filter.
6	FG_FMAG	Activates/inactivates the Fmag resultant force low-pass filter.
7	FG_TMAG	Activates/inactivates the Tmag resultant torque low-pass filter.

Note: When the number of elements is an array of 6 or 7 variables, only the element number settings 0 to 5 are acquired.

bValueFx, bValueFy, bValueFz, bValueTx, bValueTy, bValueTz, bValueFmag, bValueTmag

Name of Constants	Values	Description
False	0	Sets the low-pass filter to inactive. (default)
True	–1	Sets the low-pass filter to active.

Detailed Explanation

This activates/inactivates or returns the status of the low-pass filter in the specified axes of the force coordinate system.

It activate/inactivate the following settings.

bValueFx: Fx bValueFy: Fy bValueFz: Fz

bValueTx: Tx bValueTy : Ty bValueTz: Tz

bValueFmag: Fmag bValueTmag :Tmag

The signal noise reduction can be enhanced when the low-pass filter is activated, but the following performance for quick signal changes deteriorates.

The low-pass filter is used with AvgForces Status, PeakForces Status, the Force Trigger Function, Force Monitor, and Force Control Monitor Function, but is not used with Forces Status.

Usage Example

This example sets the low-pass filter and acquires the value where the absolute value of the torque is greatest.

```
Function GetPeakForces
    Real myPeakForces(6)
    FSet FCS1.Orientation, FG_TOOL
    FSet FM1.CoordinateSystem, FCS1
    FSet FM1.LPF_Enabled, True, True, True, True, True, True
    FSet FM1.LPF_TimeConstants, 0.02, 0.02, 0.02, 0.02, 0.02, 0.02
    FSet FM1.PeakForceClear, True, True, True, True, True, True
    Wait 10
    FGet FM1.PeakForces, myPeakForces()
    Print myPeakForces (FG_TX), myPeakForces (FG_TY), myPeakForces
(FG_TZ)
Fend
```

Reference

Force Trigger Object FT#, Force Monitor Object FM#

LPF_TimeConstants Property

Application

Force Trigger Object FT#, Force Monitor Object FM#

Comments

This sets or returns the value of the low-pass filter time constants applied to each axis in the force coordinate system at the same time.

Immediate Execution

No

Usage

FGet *Object*.**LPF_TimeConstants**, r*Array()*

FSet *Object*.**LPF_TimeConstants**, r*ValueFx, rValueFy, rValueFz, rValueTx, rValueTy, rValueTz [,rValueFmag, rValueTmag]*

Object	Object name, or string variable defining the object name The object is specified as FT (numerical value), FT (label), FM (numerical value), or FM (label).
rArray()	The element numbers defining the value of the property is and array of 6 or more real number variable
rValueFx	A real number or formula defining the new value of the property
rValueFy	A real number or formula defining the new value of the property
rValueFz	A real number or formula defining the new value of the property
rValueTx	A real number or formula defining the new value of the property
rValueTy	A real number or formula defining the new value of the property
rValueTz	A real number or formula defining the new value of the property
rValueFmag	A real number or formula defining the new value of the property
rValueTmag	A real number or formula defining the new value of the property

Values

rArray():

Element number	Element number constant	Description
0	FG_FX	This is the Fx low-pass filter time constant.
1	FG_FY	This is the Fy low-pass filter time constant.
2	FG_FZ	This is the Fz low-pass filter time constant
3	FG_TX	This is the Tx low-pass filter time constant.
4	FG_TY	This is the Ty low-pass filter time constant.
5	FG_TZ	This is the Tz low-pass filter time constant.
6	FG_FMAG	This is the Fmag resultant force low-pass filter time constant.
7	FG_TMAG	This is the Tmag resultant torque low-pass filter time constant.

Note: When the number of elements is an array of 6 or 7 variables, only the element number settings 0 to 5 are acquired.

rValueFx, rValueFy, rValueFz, rValueTx, rValueTy, rValueTz, rValueFmag, rValueTmag (Unit: [sec])

	Values
Minimum	0.002
Maximum	5

Default: 0.01

Detailed Explanation

This sets or returns the value of the low-pass filter time constants applied to each axis in the force coordinate system at the same time.

It sets the following time constant settings.

rValueFx: Fx rValueFy: Fy rValueFz: Fz

rValueTx: Fx rValueTy: Ty rValueTz: Tz

rValueFmag: Fmag rValueTmag: Tmag

The low-pass filter time constant is the time it takes to arrive at an input value of $1\text{-}e^{-1}$ (approximately 63.2%) when giving step input.

The signal noise reduction can be enhanced when increasing the time constant, but the following performance for quick signal changes deteriorates.

The low-pass filter is used with AvgForces Status, PeakForces Status, the Force Trigger Function, and Force Monitor, and Force Control Monitor Function, but is not used with Forces Status.

Usage Example

This example sets the low-pass filter and acquires the value when the maximum absolute value is attained for torque.

```
Function GetPeakForces
     Real myPeakForces(6)
     FSet FCS1.Orientation, FG_TOOL
     FSet FM1.CoordinateSystem, FCS1
     FSet FM1.LPF_Enabled, True, True, True, True, True, True
     FSet FM1.LPF_TimeConstants, 0.02, 0.02, 0.02, 0.02, 0.02, 0.02
     FSet FM1.PeakForceClear, True, True, True, True, True, True
     Wait 10
     FGet FM1.PeakForces, myPeakForces()
     Print myPeakForces (FG_TX), myPeakForces (FG_TY), myPeakForces
(FG_TZ)
Fend
```

Reference

Force Trigger Object FT#, Force Monitor Object FM#

Mass Property

Application

Mass Property Object MP#

Comments

This sets or returns the value for the robot hand and workpiece/payload.

Immediate Execution

No

Usage

MPGet *Object*.**Mass**, r*Var*

MPSet *Object*.**Mass**, r*Value*

Object Object name, or string variable defining the object name
The object is specified as either of MP (numerical value) or MP (Label).

rVar A real number variable defining the value of the property

rValue A real number or formula defining the new value of the property

Values

rValue (Unit: [kg])

	Values
Minimum	0
Maximum	Robot's maximum load capacity

Default: 0

Detailed Explanation

Sets or returns the value of the overall weight of the robot hand and workpiece/payload at the leading end side from the force sensor (not including the force sensor).

Mass Property Object is used to compensate for the effects of gravity on the force function.

Usage Example

This example carries out a motion using the force control function after setting the Mass Property Object.

```
Function GetPeakForces
   MPSet MP1.GravityCenter, 10, 10, 100
   MPSet MP1.Mass, 2
   MP 1
   Move CurPos +TLW(10) FC1 ROT
Fend
```

Reference

Mass Property Object MP#

Model Property

Application

Force Sensor Object FS#

Comments

Returns the model name of the force sensor.

Immediate Execution

No

Usage

FGet *Object*.**Model**, *sVar$*

Object	Object name, or string variable defining the object name The object is specified as FS (numerical value).
sVar$	String variable defining the property value

Detailed Explanation

This property is used when confirming the model name of the force sensor.

Usage Example

This example confirms the model name for force sensor 1.

```
Function Test_Model
    String model$
    FGet FS1.Model, model$
    Print model$
Fend
```

Reference

Force Sensor Object FS#

MotionLimited Status

Application

Force Control Object FC#

Comments

This returns which of the following velocity or acceleration limits limited the velocity or acceleration of the motion which was just carried out with force control active.

Maximum joint velocity
Maximum joint acceleration
Maximum tool position modification velocity
Maximum tool position modification acceleration
Maximum tool orientation modification velocity
Maximum tool orientation modification acceleration

Usage

FGet *Object*.**MotionLimited**, *iVar*

Object Object name, or string variable defining the object name
The object is specified as either of FC (numerical value) or FC (label).

iVar A variable defining the value of the property of the Int32 or Int64 type

Values

Bit	Results
0	Maximum tool position modification velocity
1	Maximum tool position modification acceleration
2	Maximum tool orientation modification velocity
3	Maximum tool orientation modification acceleration
4	J1 Maximum joint velocity
5	J1 Maximum joint acceleration
6	J2 Maximum joint velocity
7	J2 Maximum joint acceleration
8	J3 Maximum joint velocity
9	J3 Maximum joint acceleration
10	J4 Maximum joint velocity
11	J4 Maximum joint acceleration
12	J5 Maximum joint velocity
13	J5 Maximum joint acceleration
14	J6 Maximum joint velocity
15	J6 Maximum joint acceleration

The value of each Bit

0: No limitation

1: With limitation

Detailed Explanation

This returns which of the following velocity or acceleration limits limited the velocity or acceleration of the motion which was just carried out with force control active.

Maximum joint velocity
Maximum joint acceleration
Maximum tool position modification velocity
Maximum tool position modification acceleration
Maximum tool orientation modification velocity
Maximum tool orientation modification acceleration

Any item which limited the motion while force control was active even once will become a "1."

This is used for processing or branching based on whether a motion was limited.

MotionLimited status returns a value of 0 to 65535 (hexadecimal FFFF). Because of this, the range that can be handled with an Integer type can be exceeded. Use Int32 or Int64 type variables.

Usage Example

This is an example of branch-processing depending on whether the Move motion was limited or not.

```
Function motionLimitedTest
    Int64 Result
    FSet FCS1.Orientation, FG_TOOL     ' Sets the force coordinate data

    FSet FC1.CoordinateSystem, FCS1    ' Specifies the force coordinate data
    FSet FC1.Fx_Spring, 0              ' Sets the virtual Fx coefficient of elasticity
    FSet FC1.Fx_Damper, 1              ' Sets the virtual Fx coefficient of viscosity
    FSet FC1.Fx_Mass, 10               ' Sets the virtual Fx coefficient of inertia
    FSet FC1.Fx_Enabled, True          ' Sets the Fx force control to active
    FSet FC1.LimitAccelS, 5    ' Sets the maximum joint acceleration to 5[mm/sec^2]
    AccelS 2                   ' Sets the maximum CP motion acceleration to 2[mm/sec^2]

    Move P0 FC1                        ' A Move motion with force control active
    FGet FC1.MotionLimited, Result     ' Acquires limit result

    If Result <> 0 Then                '  When the motion is limited
        -
        -
        -
    EndIf
    -
    -
    -

Fend
```

Reference

Force Control Object FC#, LimitSpeedSRJ Property, LimitAccelSRJ Property

Move Statement

Comments

Carries out a linear interpolation motion with the force control function active.

Usage

Move *P#* [*FC#*] [ROT] [ECP] [CF] [CP] [Till | Find] [!parallel processing!] [SYNC]

P# Specifies the point data defining the target position of the motion.

FC# Specifies the force control object.

CF Continues the force control function. Can be omitted.

Detailed Explanation

By adding, as a parameter, a force control object to an ordinary Move command, a Move motion is carried out with force control active. There are instances wherein the same path is not necessarily traced as a result of the exact same command due to the path changing according to the force during the motion, and the motion may stop at a position different than the target position

The Force Control Function operates in accordance with each of the properties for the Force Control Object. Execute after confirming each of the properties for the Force Control Object.

The velocity and acceleration of the Force Control Object is limited by the LimitSpeed and LimitAccel during the operation of the force control function. Refer to the appropriate item for the all property details.

By adding CF parameter, it is possible to continue the force control function up to the next motion. By doing this, the robot proceeds to the next statement at the point the Move motion is completed, as it would ordinarily do, but the robot continues with the force control function still active. In addition, when adding a CP parameter, you then must add a CF parameter. When a CP parameter is added, continued force control function accompanies the normal path motion.

Also, the continuation of the force control by virtue of the CF parameter brings with it the following limitations on the modification of the Force Control Object.

Property name	Pre-motion parameter	Post-motion parameter	Modification advisable?
Enabled	False	True	OK
	True	False	NG
LimitAccel	Low	High	OK
	High	Low	NG
LimitSpeed	Low	High	OK
	High	Low	NG
TargetForcePriorityMode	False	True	NG
	True	False	NG
CoordinateSystem	FCSX	FCSX	OK
	FCSX	FCSY	NG

Moreover, when a CF parameter is added, a normal motion cannot be executed immediately thereafter. When desiring to execute a normal motion command after the force control function has been activated, either do not add a CF parameter or execute an FCEnd statement to inactivate the force control function.

In the same manner as an ordinary motion, when adding a Till qualifier, the movement can be terminated by certain conditions. For details on a Till qualifier, refer to the following manual and Force Trigger Object sections.

EPSON RC+ 7.0 SPEL+ Language Reference
Till

While force control is operating, Till will cause the force control function to decrease the velocity after the normal motion has been stopped. In addition, when a CF parameter is added, the motion command can be stopped, but the force control function continues. When desiring to stop the force control function as well, either do not add a CF parameter or execute an FCEnd statement.

When the motion is paused while force control is operating, the force control function cannot be re-started. Execute the next motion after the current motion has been completed.

The following commands cannot be used while the force command function is operating. Execute the following commands after executing an FCEnd statement and the force command function has ended.

Arm	Calib	Elbow	J1Angle	Local	Power	TLClr	WaitPos
ArmClr	CP	Encreset	J1Flag	LocalClr	PTPTime	TLSet	Where
ArmSet	ECP	Hand	J2Flag	Mcal	SFree	Tool	Wrist
Base	ECPClr	Here	J4Flag	Motor			
Brake	ECPSet	Home	J6Flag				

For SCARA robots (including RS series), the force control function cannot be executed in the following cases regardless of the FCS object settings referred by the FC object.

- When the V or W parameter for the base coordinate system or the selected tool coordinate system is other than 0.
- When Tx_Enabled or Ty_Enabled property for the FC object is True.

The force control function cannot be executed in the following cases when the Local coordinate system is specified for the Orientation property of the FCS object which is referred by the FC object.

- When the V or W parameter for the local coordinate system with the number which is referred by the FCS object is other than 0.

The force control function cannot be executed in the following cases when the Custom coordinate system is specified for the Orientation property of the FCS object which is referred by the FC object.

- When the V or W parameter for the Orientation property is other than 0.

The force control function cannot be executed for other than SCARA (including RS series) and 6-axis robots (including N series).

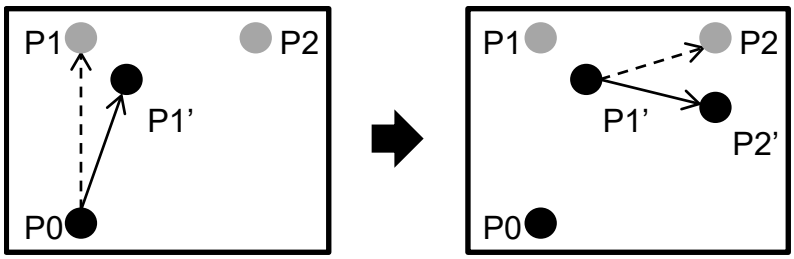
Force Control and trajectories

Use Move with FC

When a CF parameter and a CP parameter are not added, the robot is positioned each time the motion command is completed. In the subsequent command, a trajectory from the current position to the target position will be planned.

The figure below shows the motion trajectories when the following program is executed.

```
Move P1 FC1
Move P2 FC1
```



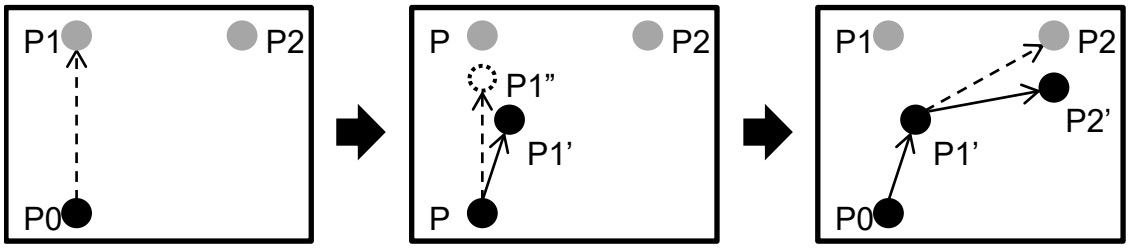
In the first Move, a trajectory from the initial position P0 to the target position P1 is planned (dotted line), and then the robot starts motion.
At this point, the robot moves to P1' because the path is corrected by the force control. (Solid line)
The robot is positioned at P1' and then stops.

In the second Move, a trajectory from P1' (where the robot is positioned) to P2 is planned (dotted line), but the robot moves to P2' because the path is corrected by the force control like the first Move. (Solid line)

Use Move with FC and Till

The figure below shows the motion trajectories when the following program which uses Till is executed.

```
Move P1 FC1 Till
Move P2 FC1
```



In the first Move, a trajectory from the initial position P0 to the target position P1 is planned (dotted line), and then the robot starts motion.
At this point, the robot moves toward P1' because the path is corrected by the force control. (Solid line)
If the Till conditions are met during the motion, the robot will be stopped and positioned at P1' instead of P1'' on the planned trajectory because of correction by the force control.

In the second Move, a trajectory from P1' (where the robot is positioned) to P2 is planned (dotted line), but the robot moves to P2' because the path is corrected by the force control like the first Move. (Solid line)

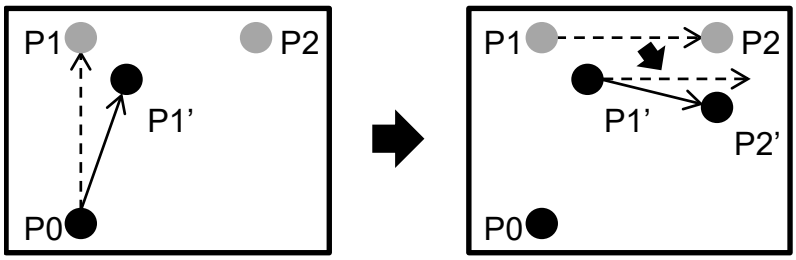
If the Till conditions are not met during the first Move motion, the robot moves in the same way as described in "Use Move with FC".

Use Move with FC and CF

When a CF parameter is added, the force control continues and the robot is not positioned even when a motion command is completed.
In the subsequent command, a trajectory is planned based on the initially planned target position and the subsequent target position.

The figure below shows the motion trajectories when the following program is executed.

```
Move P1 FC1 CF
Move P2 FC1
```



In the first Move, a trajectory from the initial position P0 to the target position P1 is planned (dotted line), and then the robot starts motion.
At this point, the robot moves to P1' because the path is corrected by the force control. (Solid line)
Since the CF parameter is added, the robot is not positioned and the force control continues.

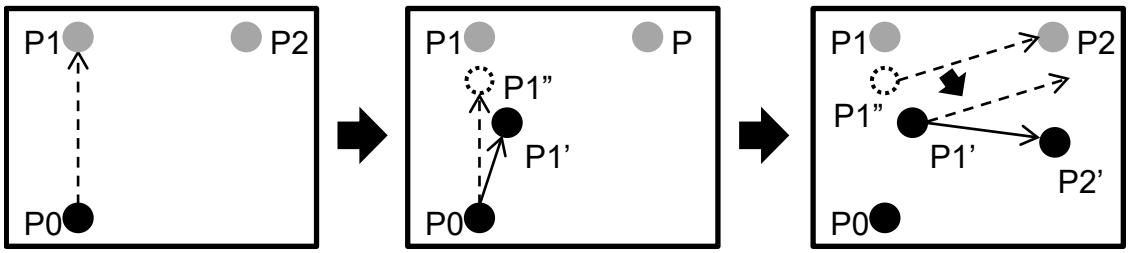
In the second Move, a trajectory from the target position of the first Move, P1, to P2 is planned. (Dotted line)
Then, the robot moves toward the position which considers the relative displacement amount from the current

position P1'. (Dotted line)
At this point, the robot moves to P2' because the path is corrected by the force control function like the first Move. (Solid line)

Use Move with FC, CF, and Till

The figure below shows the motion trajectories when the following program is executed.

```
Move P1 FC1 CF Till
Move P2 FC1
```



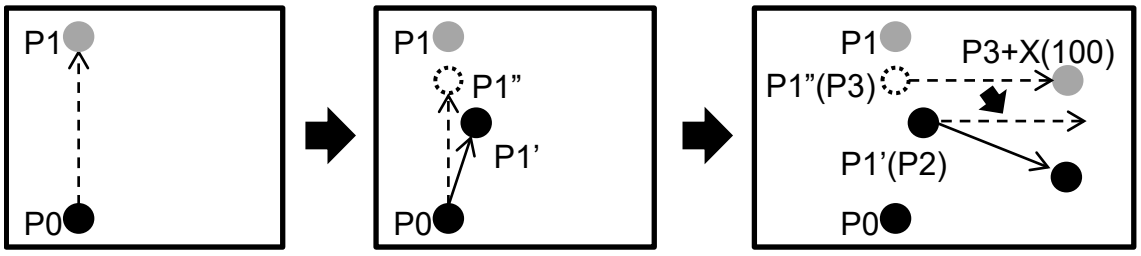
In the first Move, a trajectory from the initial position P0 to the target position P1 is planned (dashed line), and then the robot start motion.
At this point, the robot moves to P1' because the path is corrected by the force control. (Solid line)
If the Till conditions are met during the motion, the robot stops motion toward the planned trajectory. (P1")
Since the CF parameter is added, the robot is not positioned and the force control continues.

In the second Move, a trajectory from P1" (stop position on the trajectory planned for the first Move) to P2 is planned (dashed line). Then, the robot moves toward the position which considers the relative displacement amount from the current position P1'. (Dashed line)
At this point, the robot moves to P2' because the path is corrected by the force control like the first Move. (Solid line)

By using the RefPos property, the current position on the planned trajectory and actual current position can be acquired. However, if the force control is continued by the CF parameter, the actual position keeps changing. By using this, the amount of relative displacement can be specified after motion stops by Till.

The figure below shows the motion trajectories when the following program is executed.

```
Move P1 FC1 CF Till
FGet Robot.RefPos, P2, P3
Move P3 +X(100) FC1
```



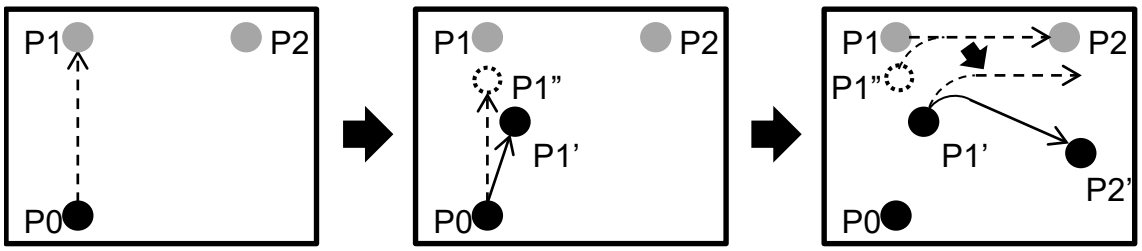
The stop position P1" on the planned trajectory at the time of motion stop by Till will be P3.
The amount of relative displacement as position control can be specified based on P3.

Use Move with FC, CF, and CP

When a CF parameter is added, the force control continues and the robot is not positioned even when a motion command is completed.
In the subsequent command, a trajectory is planned based on the initially planned target position and the subsequent target position. Also, when a CP parameter is added, the control goes to next statement at the same time as deceleration for the motion command starts. By using this, several consecutive motions can be connected.

The figure below shows the motion trajectories when the following program is executed.

```
Move P1 FC1 CF CP
Move P2 FC1
```



In the first Move, a trajectory from the initial position P0 to the target position P1 is planned (dashed line), and then the robot starts motion.
At this point, the robot moves to P1’ because the path is corrected by the force control. (Solid line)

When deceleration starts in the planned trajectory (P1’’), the second Move plans a trajectory between P1 (the target position of the first Move) and P2, and then combine it to the planned trajectory of the first Move. (Curved dashed line)
The robot starts motion toward the position which considers the relative displacement amount from the current position P1’. (Dashed line)
At this time, the robot moves to P2’ because the path is corrected continuously by the force control. (Solid line)

Use Move with FC, CF, CP, and Till

When the force control objects, CF parameter, CP parameter and Till qualifier are used together, the robot moves as below.

```
Move P1 FC1 CF CP Till
Move P2 FC1
```

If the Till conditions are met before the first Move starts deceleration, the robot moves in the same way as described in “Use Move with FC, CF, and Till”.

If the Till conditions are not met before the first Move starts deceleration, the robot moves in the same way as described in “Use Move with FC, CF, and CP”. Since the next motion command is executed at the same time as the start of deceleration, conditional judgement for Till is also completed simultaneously.

Usage Example

This is a simple programming example of a executing a Move motion with force control active.

This example executes a Move motion with force control active in the X axis direction of the tool's coordinate system.

```
Function ForceMoveTest
    FSet FCS1.Orientation, FG_TOOL        ' Sets the force coordinate data

    FSet FC1.CoordinateSystem, FCS1       ' Specifies the force coordinate data
    FSet FC1.Fx_Spring, 0                 ' Sets virtual Fx coefficient of elasticity
    FSet FC1.Fx_Damper, 1                 ' Sets virtual Fx coefficient of viscosity
    FSet FC1.Fx_Mass, 10                  ' Sets virtual Fx coefficient of inertia
    FSet FC1.Fx_Enabled, True             ' Activates Fx force control function

    Move P0 FC1                           ' Move motion with force control active
Fend
```

Next is an example of a program using a CF parameter.

In this example, Force Control Object FC1 is used to execute the force control function while moving from the current position to P0 and then to P1. The force control function will be terminated at the completion of the movement. After that, the movement will proceed to P2 and then to P3 using Force Control Object FC2 to execute the force control function. When the movement to P3 has been completed, the force control function will remain active due to the CF parameter, but the force control function will be terminated via that FCEnd statement. Following that, Force Control Object FC3 is used to continue the force control until 5 seconds have passed after arriving at P4. In order to maintain the active state of the force control function for a certain amount of time following a movement, use the FCKeep statement.

For details on FCKeep and FCend, please refer to the details for each statement.

```
Function ForceMoveCFTest
    Move P0 FC1 CF
    Move P1 FC1

    Move P2 FC2 CF
    Move P3 FC2 CF
    FCEnd

    Move P4 FC3 CF
    FCKeep FC3, 5
Fend
```

Next is an example of a program using a Till qualifier.

Establish Force Trigger Object FT1 for Till, and add a Till qualifier to the Move motion command with force control active. When Till becomes active during the movement to P1, the Move motion and the force control function are terminated and the robot stops. The same thing happens during the movement to P2. When Till becomes active on the way to P3, the Move motion is terminated due to the addition of the CF parameter, but the force control function remains active. For that reason the robot does not stop. After that, the movement progresses to P4 with the force control function remaining active.

```
Function ForceMoveTillTest
    Till FT1
    Move P1 FC1 Till        ' Both the motion and the force control function are terminated
    Move P2 FC2 Till        ' Both the motion and the force control function are terminated

    Move P3 FC3 CF Till     ' The motion is terminated, but the force control function
continues
    Move P4 FC3
Fend
```

Reference

Move, Force Control Object FC#, Force Trigger Object FT#, Till, FCKeep, FCEnd

MP Statement

Application

Mass Property Object MP#

Comments

This sets or returns the value of the Mass Property used with gravity compensation.

Immediate Execution

Yes

Usage

MP *[iValue]*

iValue A number defining the new Mass Property

Detailed Explanation

This sets or returns the value of the Mass Property used with gravity compensation. With no argument, the current number will be displayed in the command window or run window. The argument can be set to 0 to 15. 0 is the setting to stop gravity compensation.

When the Mass Property is changed, execute the Reset Property.

Reference

Mass Property Object MP#

MPDef Function

Application

Mass Property Object MP#

Comments

This returns whether the Mass Property Object is defined or not.

Usage

MPDef*(Object)*

Object Mass Property Object name or string variable defining the Mass Property Object name
Mass Property Object is specified as either of MP (numerical value) or MP (label).

Return Values

“True” if the specified force object is defined, “False” if undefined.

Detailed Explanation

This returns whether the specified Mass Property Object is defined or not.

Usage Example

This is an example of displaying that the Mass Property Object is defined.

```
Function main
   If MPDef(MP9) Then
      Print "MP9 is defined"
   EndIf
Fend
```

Reference

Mass Property Object MP#

MPDel Statement

Application

Mass Property Object MP#

Comments

This deletes the specified Mass Property Object.

Immediate Execution

Yes

Usage

MPDel *Object1 [, Object2]*

Object1 The Mass Property Object starting the object data range to be deleted or a string variable defining the Mass Property Object.

Object2 The Mass Property Object ending the object data range to be deleted or a string variable defining the Mass Property Object.

Detailed Explanation

This is used to delete the specified Mass Property Object while the program is being executed. The object data from the start object parameter to the end object parameter is deleted. The start object and the end object must be a Mass Property Object. Moreover, make the number of the start object smaller than the number of the end object. No error occurs when the object is not defined.

Usage Example

This is an example of deleting the Mass Property Object.

```
> MPDel MP1              ' Deletes Mass Property Object 1
> MPDel MP2, MP10        ' Deletes Mass Property Object 2 through 10
```

Reference

Mass Property Object MP#

MPGet Statement

Application

Mass Property Object MP#

Comments

This is used when obtaining the value of the properties of the Mass Property Object.

Usage

MPGet *Object.Property, Var*

Object	Object name, or string variable defining the object name The object is specified as either of MP (numerical value) or MP (Label).
Property	The name of the property for which the value is to be acquired
Var	The variable which expresses the returned value The numbers and format differ according to the property.

Detailed Explanation

This is used when obtaining the value of the properties of the Mass Property Object.

Usage Example

This example sets the values of the Mass Property Object, acquires those values, and then displays them.

```
Function MPTest

    Integer iVar
    String sVar$

    'The setting of each property
    MPSet MP1.Label, "MP1_Label"
    MPSet MP1.Description, "MP1_Description"
    MPSet MP1.Mass, 1
    MPSet MP1.GravityCenter, 0, 0, 100

    'Acquiring the numbers
    MPGet MP(MP1_Label).Number, iVar
    Print iVar
    'Acquiring the labels
    MPGet MP((iVar)).Label, sVar$
    Print sVar$
Fend
```

Reference

FSet

MPLabel$ Function

Application

Mass Property Object MP#

Comments

Returns the Mass Property Object label.

Usage

MPLabel$(*Object***)**

Object The Mass Property Object name or a string variable defining the Mass Property Object name Mass Property Object is specified as either of MP (numerical value) or MP (label).

Return Values

Detailed Explanation

Detailed Explanation

Returns the Mass Property Object label.

Usage Example

This example sets the Mass Property Object label and displays it.

```
> MPSet MP1.Label, "Label1"
> Print MPLabel$(MP1)
Label1
```

Reference

Label Property, Mass Property Object MP#

MPList Statement

Application

Mass Property Object MP#

Comments

Displays a list of Mass Property Objects.

Immediate Execution

Yes

Usage

MPList *Object1 [, [Object2]]*

Object1 The Mass Property Object name starting the object data range to be listed, or a string variable defining the Mass Property Object name.

Object2 The Mass Property Object name ending the object data range to be listed, or a string variable defining the Mass Property Object name.

Detailed Explanation

The defined object data from the specified start object to the specified end object is displayed in the Command window or Run window.

When “,” and the end object are omitted, only the start object is displayed, and when “,” is used and the end object is omitted, all objects from the start object on are displayed.

The output format for each line is the same format as the parameter for the MPSet Statement.

Object.Property, Values

Object Object name

Property Property name

Values The number or format expressing the value depends on the property

Usage Example

This example lists the Mass Property Object data.

```
> MPList MP1
MP1.Label, "Label1"
MP1.Mass, 0
MP1.GravityCenter, 0, 0, 0
MP1.Inertia, 0
MP1.Description, ""
```

Reference

Mass Property Object MP#

MPNumber Function

Application

Mass Property Object MP#

Comments

Returns the Mass Property Object number matching the specified Mass Property Object label.

Usage

MPNumber(*Object***)**

Object The Mass Property Object name or string variable defining the Mass Property Object name Mass Property Object is specified as MP (label).

Return Values

Integers

Detailed Explanation

Returns the Mass Property Object number matching the specified Mass Property Object label.
An error occurs when there is not matching object.

Usage Example

This example specifies the label for the Mass Property Object, then acquires the number from the label.

```
> MPSet MP1.Label, "Label1"
> Print MPNumber(MP(Label1))
 1
```

Reference

Mass Property Object MP#

MPSet Statement

Application

Mass Property Object MP#

Comments

Used when setting the Mass Property Object value.

Usage

MPSet *Object.Property, Values*

Object Object name, or string variable defining the object name
The object is specified as either of MP (numerical value) or MP (Label).

Property Property name defining the new value

Values Parameter
The numbers and format differ according to the property.

Detailed Explanation

This is used for setting the properties of Mass Property Objects.

Usage Example

This example sets the value of the Mass Property Object, then acquires that value and displays it.

```
Function MPTest

    Integer iVar
    String sVar$

    'Set each property
    MPSet MP1.Label, "MP1_Label"
    MPSet MP1.Description, "MP1_Description"
    MPSet MP1.Mass, 1
    MPSet MP1.GravityCenter, 0, 0, 100

    'Acquires the number
    MPGet MP(MP1_Label).Number, iVar
    Print iVar
    'Acquires the label
    MPGet MP((iVar)).Label, sVar$
    Print sVar$
Fend
```

Reference

FGet, FSave, ForceObject

Number Property

Application

Force Control Object FC#, Force Trigger Object FT#,
Force Monitor Object FM#, Force Coordinate System Object FCS#, Mass Property Object MP#

Comments

This references the number of the object by type.

Immediate Execution

No

Usage

FGet *Object*.**Number**, *Var*

MPGet *MPObject*.**Number**, *Var*

Object The force object name, or string variable defining the name of the object
The force object is specified as FC (label), FCS (label) FT (label), or FM (label).

MPObject Mass Property Object name, or string variable defining the name of the Mass Property Object.
The Mass Property Object is specified as MP (label).

Var A real number variable defining the value of the property

Detailed Explanation

This references the number of the object by type. This cannot be set.

This differs from the specifying of other properties and objects. Other properties can be specified by number and label. For Number Property, objects are specified by label only.

Reference

Force Control Object FC#, Force Trigger Object FT#,
Force Monitor Object FM#, Force Coordinate System Object FCS#, Mass Property Object MP#

Operator Property

Application

Force Trigger Object FT#

Comments

This sets or returns the trigger conditions for Force Trigger Objects.

Immediate Execution

No

Usage

FGet *Object*.**Operator**, *iVar*

FSet *Object*.**Operator**, *iValue*

Object	An object or a string variable defining the name of the object The object is specified as either of FT (numerical value) or FT (label).
iVar	An integer variable defining the value of the property
iValue	An integer value or formula defining the new value of the property.

Values

iValue

Name of Constants	Values	Description
FG_OR	0	OR condition (default)
FG_AND	1	AND condition

Detailed Explanation

When OR conditions are selected, the trigger is pulled when any one of the conditions active in the XX_Enable Property is met.

When AND conditions are selected, the trigger is pulled when all of the conditions active in the XX_Enable Property are met.

Usage Example

This is an example of a program where the force trigger is pulled when the X axis and Y axis conditions are met.

```
Function Test_Operator
    Integer iVar
    FSet FT1.Fx_Enabled, True    ' Activates X axis
    FSet FT1.Fy_Enabled, True    ' Activates Y axis
    FSet FT1.Operator, FG_AND    ' Sets the trigger condition to an AND condition
    FGet FT1.Operator, iVar      ' Confirms the current trigger conditions
    Print iVar
Fend
```

Reference

Force Trigger Object FT#

Orientation Property

Application

Force Coordinate System Object FCS#

Comments

This sets or returns the orientation of the coordinate axis in the force coordinate system.

The local coordinate system number is only set when Local is selected for the coordinate axis.

u, v, and w can be set only when “Custom” is selected for the coordinate axis.

Immediate Execution

No

Usage

FGet *Object*.**Orientation**, r*Array()*

FSet *Object*.**Orientation**, i*Value*

FSet *Object*.**Orientation**, *iValue, iValueL*

FSet *Object*.**Orientation**, i*Value, rValueU, rValueV, rValueW*

Object Object name, or string variable defining the object name
The object is specified as either of FCS (numerical value) or FCS (label).

rArray() The maximum number of elements to define the value of the property is an array of 6 or more real number variables

iValue A real number or formula defining the new value of the property

iValueL A real number or formula defining the new value of the property

rValueU A real number or formula defining the new value of the property

rValueV A real number or formula defining the new value of the property

rValueW A real number or formula defining the new value of the property

Values

rArray

Element number	Element number constant	Description
0	FG_CRD_SYS	Coordinate system
1	FG_LOCAL_NO	Local coordinate number
2	-	-
3	FG_U	The relative FG_CUSTOM orientation for the U axis rotation amount
4	FG_V	The relative FG_CUSTOM orientation for the V axis rotation amount
5	FG_W	The relative FG_CUSTOM orientation for the W axis rotation amount

iValue

Name of Constants	Values	Description
FG_BASE	0	Defines the direction of the base coordinate system
FG_LOCAL	1	Defines the direction of the local coordinate system
FG_TOOL	2 (default)	Defines the direction of the tool coordinate system
FG_CUSTOM	3	Defines the direction of the custom coordinate system

iValueL

	Values
Minimum	0
Maximum	15

Default: 0

rValueU, rValueV, rValueW

	Values
Minimum	–360
Maximum	360

Default: 0

Detailed Explanation

Sets or returns the orientation of the force coordinate coordinate-axis.

The first argument, “iValue”, sets the coordinate system.

FG_BASE	:	The direction of the axis for the base coordinate system is set in the force coordinate system.
FG_LOCAL	:	The direction of the axis for the local coordinate system is set in the force coordinate system. In this case, the number for the local coordinate system is set as the second argument.
FG_TOOL	:	The direction of the axis for the tool coordinate system is set in the force coordinate system.
FG_CUSTOM	:	The direction of the axis for the coordinate system set off of the tool coordinate system as the datum is set in the force coordinate system. The relative orientation modification amount for U, V, and W axes from the tool coordinate system are set for the 2nd to 4th arguments.

FG_BASE and FG_LOCAL become the stationary coordinate systems for the direction of the axes during motions.

FG_TOOL and FG_CUSTOM become dynamic coordinate systems for robot orientation modification as well as for the direction of the axes during motion.

The datum for all coordinate system is the coordinate system used when using the force control function, the force trigger function, or force monitor function.
After setting the Orientation property, should the coordinate system serving as the datum for the Base, Local, and Tool statements be changed, the coordinate system established when setting the Orientation property is not used, but the coordinate system used when using the force function is applied.

Usage Example

This example sets the origin and coordinate axes for force coordinate 1, then sets force coordinate 1 as the Force Monitor Object, and acquires the force data.

```
Function GetForces
     Real myForces(8)
     FSet FCS1.Position, 0, 0, 100
     FSet FCS1.Orientation, FG_TOOL
     FSet FM1.CoordinateSystem, FCS1
     FGet FM1.Forces, myForces()
     Print myForces(FG_TX), myForces(FG_TY), myForces(FG_TZ)
 Fend
```

Reference

Force Coordinate System Object FCS#

PeakForceClear Property

Application

Force Monitor Object FM#

Comments

This activates/inactivates the force and torque peak value calculations at the same time.

Immediate Execution

Yes

Usage

FSet *Object*.**PeakForceClear**, bValue*Fx, bValueFy, bValueFz, bValueTx, bValueTy, bValueTz [, bValueFmag, bValueTmag]*

Object	Object name or string variable defining object name The object is specified as either of FM (numerical value) or FM (label).
bValueFx	A Boolean value or formula defining the new value of the property
bValueFy	A Boolean value or formula defining the new value of the property
bValueFz	A Boolean value or formula defining the new value of the property
bValueTx	A Boolean value or formula defining the new value of the property
bValueTy	A Boolean value or formula defining the new value of the property
bValueTz	A Boolean value or formula defining the new value of the property
bValueFmag	A Boolean value or formula defining the new value of the property
bValueTmag	A Boolean value or formula defining the new value of the property

Values

bValueFx, bValueFy, bValueFz, bValueTx, bValueTy, bValueTz, bValueFmag, bValueTmag

Name of Constants	Values	Description
False	0	Inactivates the subject axis. (default)
True	–1	Activates the subject axis.

Detailed Explanation

PeakForces activates/inactivates the force and torque peak value calculations at the same time.

Be sure to execute PeakForceClear before executing PeakForces.

Usage Example

This example returns the value of the peak force in the Fx direction.

```
Function CheckPeakForces
    Double PF(7)
    FSet FC1.Enabled, True, False, False, False, False, False
    FSet FC1.TargetForces, 10, 0, 0, 0, 0, 0
    FSet FS1.Reset
    FSet FM1.CoordinateSystem, FCS0
    FSet FM1.PeakForceClear, True, False, False, False, False,
                             False, False, False
    FCKeep FC1, 10
    FGet FM1.PeakForces, PF()
    Print PF(FG_FX)
Fend
```

Reference

Force Monitor Object FM#

PeakForces Status

Application

Force Monitor Object FM#

Comments

Returns the values of peak / minimum / maximum force and torque simultaneously. The minimum values and the maximum values can be omitted.

Usage

FGet *Object*.**PeakForces**, r*ArrayPeak()*

FGet *Object*.**PeakForces**, r*ArrayPeak()*, r*ArrayMin()*, r*ArrayMax()*

Object Object name or string variable defining object name
The object is specified as either of FM (numerical value) or FM (label).

rArrayPeak() The number of elements defining the value of the property is an array of 6 or more real number variables

rArrayMin() The number of elements defining the value of the property is an array of 6 or more real number variables

rArrayMax() The number of elements defining the value of the property is an array of 6 or more real number variables

Values

rArrayPeak()

Element number	Element number constant	Description
0	FG_FX	Acquires the value of peak Fx force.
1	FG_FY	Acquires the value of peak Fy force.
2	FG_FZ	Acquires the value of peak Fz force.
3	FG_TX	Acquires the value of peak Tx torque.
4	FG_TY	Acquires the value of peak Ty torque.
5	FG_TZ	Acquires the value of peak Tz torque.
6	FG_FMAG	Acquires the value of peak Fmag resultant force.
7	FG_TMAG	Acquires the value of peak Tmag resultant torque.

rArrayMin()

Element number	Element number constant	Description
0	FG_FX	Acquires the value of minimum Fx force.
1	FG_FY	Acquires the value of minimum Fy force.
2	FG_FZ	Acquires the value of minimum Fz force.
3	FG_TX	Acquires the value of minimum Tx torque.
4	FG_TY	Acquires the value of minimum Ty torque.
5	FG_TZ	Acquires the value of minimum Tz torque.
6	FG_FMAG	Acquires the value of minimum Fmag resultant force.
7	FG_TMAG	Acquires the value of minimum Tmag resultant torque.

rArrayMax()

Element number	Element number constant	Description
0	FG_FX	Acquires the value of maximum Fx force.
1	FG_FY	Acquires the value of maximum Fy force.
2	FG_FZ	Acquires the value of maximum Fz force.
3	FG_TX	Acquires the value of maximum Tx torque.
4	FG_TY	Acquires the value of maximum Ty torque.
5	FG_TZ	Acquires the value of maximum Tz torque.
6	FG_FMAG	Acquires the value of maximum Fmag resultant force.
7	FG_TMAG	Acquires the value of maximum Tmag resultant torque.

Note: When the number of elements is an array of 6 or 7, the element numbers acquired are 0 to 5.

Detailed Explanation

PeakForces returns values of peak / minimum / maximum force and torque simultaneously while executing PeakForceClear and then PeakForces. The peak values are the maximum absolute value with a sign. The minimum and the maximum values include a sign.

Be sure to execute PeakForceClear before executing PeakForces.

Usage Example

This example returns the value of the peak force in the Fx direction.

```
Function CheckPeakForces
    Double PF(7)
    FSet FC1.Enabled, True, False, False, False, False, False
    FSet FC1.TargetForces, 10, 0, 0, 0, 0, 0
    FSet FS1.Reset
    FSet FM1.CoordinateSystem, FCS0
    FSet FM1.PeakForceClear, True, False, False, False, False,
                             False, False, False
    FCKeep FC1, 10
    FGet FM1.PeakForces, PF()
    Print PF(FG_FX)
Fend
```

Reference

Force Monitor Object FM#

PeakForces Result

Comments

Returns the peak values of force and torque during execution of a force guide object or force guide sequence.

Usage

FGGet *Sequence*.**PeakForces**, *rArray()*

FGGet *Sequence.Object*.**PeakForces**, *rArray()*

Sequence	Force guide sequence name or string variable representing force guide sequence name
Object	Force guide object name or string variable representing force guide object name. Omitted when a result of a force guide sequence is acquired.
rArray	Real array variable with six or more elements showing returned values

Values

rArray()

Element number	Element number constant	Description
0	FG_FX	Acquires the peak value of force in Fx direction during execution of a force guide sequence or force guide object.
1	FG_FY	Acquires the peak value of force in Fy direction during execution of a force guide sequence or force guide object.
2	FG_FZ	Acquires the peak value of force in Fz direction during execution of a force guide sequence or force guide object.
3	FG_TX	Acquires the peak value of torque in Tx direction during execution of a force guide sequence or force guide object.
4	FG_TY	Acquires the peak value of torque in Ty direction during execution of a force guide sequence or force guide object.
5	FG_TZ	Acquires the peak value of torque in Tz direction during execution of a force guide sequence or force guide object.

Detailed Explanation

Returns the peak values of force and torque during execution of a force guide object or force guide sequence.

Peak value is the largest absolute value of the force and torque during execution of a force guide object or a force guide sequence.

If the number of elements in a specified array variable is less than six, returns force and torque in each direction for the defined element numbers. Also, if the number of elements in the array variable exceeds six, returns force and torque in each direction from element number 0 to 5, while making no change to element number 6 and above.

Usage Example

The following is an example of a simple program that acquires a result with FGGet.

```
Function PeakForceTest
     Double dArray(6)

     Motor On

     FGRun Sequence1
     FGGet Sequence1.Contact01.PeakForces, dArray()   ' Acquisition of
PeakForces
     Print dArray(FG_FX)

 Fend
```

Reference

FGGet, force guide sequence, Contact object, Relax object, FollowMove object, SurfaceAlign object, PressProbe object, ContactProbe object, Press object, PressMove object

Polarities Property

Application

Force Trigger Object FT#

Comments

This returns the status of or sets whether the force trigger is triggered for each axis by the value being either within the thresholds or outside of the thresholds.

Immediate Execution

No

Usage

FGet *Object*.**Polarities**, i*Array()*

FSet *Object*.**Polarities**, *iValueFx, iValueFy, iValueFz, iValueTx, iValueTy, iValueTz [, iValueFmag, iValueTmag]*

Object	Object name, or string variable defining the object name The Object needs to be specified as either of FT (numerical value) or FT (label).
iArray()	The number of elements defining the value of the property is an array of 6 or more real number variables
iValueFy	An integer value or formula defining the new value of the property
iValueFz	An integer value or formula defining the new value of the property
iValueTx	An integer value or formula defining the new value of the property
iValueTy	An integer value or formula defining the new value of the property
iValueTz	An integer value or formula defining the new value of the property
iValueFmag	An integer value or formula defining the new value of the property
iValueTmag	An integer value or formula defining the new value of the property

Values

iArray()

Element number	Element number constant	Description
0	FG_FX	Returns whether the Fx force trigger is triggered by values within or outside of the threshold values.
1	FG_FY	Returns whether the Fy force trigger is triggered by values within or outside of the threshold values.
2	FG_FZ	Returns whether the Fz force trigger is triggered by values within or outside of the threshold values.
3	FG_TX	Returns whether the Tx force trigger is triggered by values within or outside of the threshold values.
4	FG_TY	Returns whether the Ty force trigger is triggered by values within or outside of the threshold values.
5	FG_TZ	Returns whether the Tz force trigger is triggered by values within or outside of the threshold values.
6	FG_FMAG	Returns whether the Fmag resultant force trigger is triggered by values within or outside of the threshold values.
7	FG_TMAG	Returns whether the Tmag resultant torque trigger is triggered by values within or outside of the threshold values.

Note: When the number of elements is an array of 6 or 7, the element numbers acquired are 0 to 5

iValueFx, iValueFy, iValueFz, iValueTx, iValueTy, iValueTz, iValueFmag, iValueTmag (Unit: Number)

Name of Constants	Values	Description
FG_OUT	0	Sets to active when over or under the upper and lower threshold values, respectively. (default)
FG_IN	1	Sets to active when within the upper threshold and lower threshold values.

Detailed Explanation

Polarities returns the status of or sets whether the force trigger is triggered for each axis by the value being either within the thresholds or outside of the thresholds.

When setting the trigger for each axis at the same time, this allows one to set all of them with fewer lines than setting them 1 axis at a time.

Usage Example

This example will generate an error and stop the robot if force, torque, resultant force or resultant torque is above the upper threshold or below the lower threshold.

```
Function SettingPolarities
    FSet FT1.Enabled, True, True, True, True, True, True, True, True
    FSet FT1.Polarities, FG_OUT, FG_OUT, FG_OUT, FG_OUT, FG_OUT,
                         FG_OUT,FG_OUT, FG_OUT
    FSet FT1.LowerLevels, -50, -50, -50, -3000, -3000, -3000, 0, 0
    FSet FT1.UpperLevels, 50, 50, 50, 3000, 3000, 3000, 50, 3000
    Trap 1, FT1 Call ForceError
Fend

Function ForceError
    AbortMotion All
Fend
```

Reference

Force Trigger Object FT#

Position Property

Application

Force Coordinate System Object FCS#

Comments

This sets the position of the origin in the force coordinate system for the selected tool coordinate system.

Immediate Execution

No

Usage

FGet *Object*.**Position**, r*Array()*

FSet *Object*.**Position**, *rValueX, rValueY, rValueZ*

Object Object name, or string variable defining the object name
The object is specified as either of FCS (numerical value) or FCS (label).

rArray() The number of elements defining the value of the property is an array of 3 or more real numbers

rValueX A real number or formula defining the new value of the property.

rValueY A real number or formula defining the new value of the property.

rValueZ A real number or formula defining the new value of the property.

Values

rArray()

Element number	Element number constant	Description
0	FG_X	Acquires the position in the X direction of the force coordinate system for the selected tool coordinate system.
1	FG_Y	Acquires the position in the Y direction of the force coordinate system for the selected tool coordinate system.
2	FG_Z	Acquires the position in the Z direction of the force coordinate system for the selected tool coordinate system.

rValueX, rValueY, rValueZ (Unit: [mm])

	Values
Minimum	–2000
Maximum	2000

Default: 0

Detailed Explanation

This sets the position of the force coordinate system in the tool coordinate system being used using the tool center point as the datum.
When the datum coordinate system is changed via the Tool or TLSet statements after the Position property are set, the coordinate system established when setting the Position property is not used, but the coordinate system used when using the force function is applied.

Usage Example

This is an example of a simple motion program using Position.

```
Function PositonTest
     Double ForceValue(8)
     FSet FCS1.Position, 100, 0, 0      ' Sets the position
     FSet FCS1.Orientation, FG_TOOL     ' Sets the direction

     FSet FM1.CoordinateSystem, FCS1    ' Specifies the force coordinate data
     FSet FM1.ForceSensor, FS1          ' Sets the number of the force sensor to be
used

     Tool 1                             ' Selects Tool1
     FGet FM1.Forces, ForceValue()      ' Acquires sensor reading for the X:100
position
                                          of Tool1

     Tool 2                             ' Selects Tool2
     FGet FM1.Forces, ForceValue()      ' Acquires sensor reading for the X:100
position
                                          of Tool2
Fend
```

Reference

Force Coordinate System Object FCS#

Reboot Property

Application

Force Sensor Object FS#

Comments

This reboots the force sensor.

Immediate Execution

Yes

Usage

FSet *Object*.**Reboot**

Object Object name, or string variable defining the object name
The object is specified as FS (numerical value).

Detailed Explanation

This reboots the force sensor when Reboot Property is executed. It takes about 10 seconds to reboot the force sensor.

CAUTION	■ Be sure to reset the Force Sensor with no external force applied to it. If it is reset with an external force applied to it, the state in which an external force applied is “0”. Therefore, if the force applied is removed, the Force Sensor detects a force even if no force is applied. If the force control function is performed in this state, the robot may move unintentionally. Caution is required in this regard.

Usage Example

This example reboots the force sensor.

```
> FSet FS1.Reboot
```

Reference

Force Sensor Object FS#

RecordEnd Property

Application

Force Monitor Object FM#

Comments

Ends recording of sensor values, robot position/orientation, and StepID that starts by RecordStart property.

Immediate Execution

Yes

Usage

FSet *Object*.**RecordEnd**

Object Object name or string variable defining object name
The object is specified as either of FM (numerical value) or FM (label).

Detailed Explanation

Recording of the data is started by RecordStart property. This property is used to stop recording the data before the measurement time specified by RecordStart property elapses.

Usage Example

This is an example to start and stop the data recording using RecordStart. The recording starts to acquire the data with intervals of 0.1 seconds for 60 seconds, and then stops after 10 seconds by the RecordEnd property. In this example, the Wait statement is used to halt the data recording, but it can be replaced by motion commands to record the force and robot position during the motion.

```
Function RecordEndTest
    FSet FM1.ForceSensor, 1
    FSet FM1.RecordStart, 60, 0.1
    Wait 10
    FSet FM1.RecordEnd
Fend
```

Reference

Force Monitor Object FM#

RecordStart Property

Application

Force Monitor Object FM#

Comments

Begins recording of sensor values, robot position/orientation, StepID, and the time of data acquisition.

Immediate Execution

Yes

Usage

FSet *Object*.**RecordStart,** *rValueD, rValueI*

FSet *Object*.**RecordStart,** *rValueD, rValueI ,sValue$*

Object	Object name or string variable defining object name The object is specified as either of FM (numerical value) or FM (label).
rValueD	A real number or formula defining the new value of the property
rValueI	A real number or formula defining the new value of the property
sValue$	An string or formula defining the new value

Values

rValueD (measurement time unit: [sec])

	Values
Minimum	1*
Maximum	600*

Default: None

rValueI (measurement interval unit: [sec])

	Values
Minimum	0.002*
Maximum	10*

Default: None

* However, “measurement time / measurement interval” should be 30,000 or less.

sValue$

32 single-byte, 16 double-byte alphanumeric characters, Japanese, and the underscore can be used.

Detailed Explanation

This property is used to start recording the sensor values, robot position and orientation, StepID, and measurement timing.

This property is available when the Controller is connected to RC+. If this property starts without connecting to RC+, any error will not be caused and the program proceeds to next statement. However, a file is not created.
The product of specified measurement time and interval “measurement time / measurement interval” cannot exceed 30,000.
This property can start the two data recording at the maximum in parallel. When starting the two data recording in parallel, stop the execution of the force monitor or the force guide sequence.
Also, it is not possible to start the data recording by using the same robot and force monitor object in parallel. To start the two data recording in parallel, use different force monitor objects.
In addition, this property cannot be used together with the LogStart property or force control monitor.

This property stops recording when the task ends, the measurement time ends, or the RecordEnd property is executed.

You can specify a saving file by sValue$. Extension is added automatically. If omitting sValue$, file name is automatically set by the label of specified FM object and the start time.

Format:

Label of FM object_time(yyyy/mm/dd)_time(hh:mm:ss:ms).csv

Example : Label of FM object: MyFMLabel
Start time: January 2nd, 2017 3 (h) 4(m) 5 (s) 006 (ms)
MyFMLabel _170102_030405006.csv

File format:

Save file is CSV format. The following information is recorded.

1st row: Item name of file’s header information
2nd row: File’s header information
3rd row: Item name of data
After 4th row: Actual values
A row before final row: Item name of footer information
Final row: File’s footer information

File used for saving the force monitor or executing force guide sequence is the same file format.

Header information of file:

Start Time, File Type, File Version, Channel, Mode, Duration[sec], Interval[sec], Robot No, Robot Name, Sensor No, Sensor Serial, Sensor Label, FM No, FM Label, FCS No, FCS Label, Seq No, Seq Name, RobotLocal

Data:

ElapsedTime[msec], Fx Force[N], Fy Force[N], Fz Force[N], Tx Force[N·mm], Ty Force[N·mm], Tz Force[N·mm], Fmag Force[N], Tmag Force[N·mm], CurPos(X)[mm], CurPos(Y)[mm], CurPos(Z)[mm], CurPos(U)[deg], CurPos(V)[deg], CurPos(W)[deg], RefPos(X)[mm], RefPos(Y)[mm], RefPos(Z)[mm], RefPos(U)[deg], RefPos(V)[deg], RefPos(W)[deg], Diff(X)[mm], Diff(Y)[mm], Diff(Z)[mm], TCPSpeed[mm/sec], TCPSpeed(X)[mm/sec], TCPSpeed(Y)[mm/sec], TCPSpeed(Z)[mm/sec], Joint(J1)[deg], Joint(J2)[deg], Joint(J3)[deg], Joint(J4)[deg], Joint(J5)[deg], Joint(J6)[deg], OLRate(J1), OLRate(J2), OLRate(J3), OLRate(J4), OLRate(J5), OLRate(J6), FCOn, StepID, Seq No, Object No, Time

Footer information of file

EndTime, EndCondition, ErrorNo, ErrorMessage

Item	Unit	Description
Start Time	–	Time when the measurement is started. Displayed in a format of “yyyy/mm/dd hh:mm:ss:ms”
File Type	–	File types. Described with Motion.
File Version	–	File version.
Channel	–	Channel number used for data output. It is record in either “1” or “2”.
Mode	–	It is a mode of recording The following information is recorded: 0: Show force monitor records 1: Show records of RecordStart property 2: Show records of force guide sequence execution
Duration	sec	Measurement time specified at the measurement.
Interval	sec	Measurement interval specified at the measurement.
Robot No	–	Robot number to be measured.
Robot Name	–	Robot name to be measured.
Sensor No	–	Force sensor number to be measured.
Sensor Serial	–	Serial number of force sensor
Sensor Label	–	Label set to force sensor
FM No	–	Number of the specified force monitor object.
FM Label	–	Label of the specified force monitor object.
FCS No	–	Number of the specified force coordinate system object
FCS Label	–	Label of the specified force coordinate object.
Seq No	–	Number of the sequence executed by force guide sequence.
Seq Name	–	Name of the sequence executed by force guide sequence.
RobotLocal	–	RobotLocal property value of the specified force monitor object.
ElapsedTime	msec	Elapsed time from the start of the measurement.
Fx Force to Fz Force Tx Force to Tz Force	N Nmm	Sensor values of each axis in force coordinate system.
Fmag Force	N	Resultant force in force coordinate system.
Tmag Force	Nmm	Resultant torque in force coordinate system.
CurPos(X) to CurPos(Z) CurPos(U) to CurPos(W)	mm deg	Command position reflecting the position control-command position and the effects of force control.
RefPos(X) to RefPos(Z) RefPos(U) to RefPos(W)	mm deg	Command-position which reflects only the position control.
Diff(X) to Diff(Z)	Mm	Difference between a direction of command reflecting the position control-command position and the effects of force control, and a direction of command which reflects only the position control. Express correction amount by force control function.
TCPSpeed	mm/sec	Tool tip speed in base coordinate system of the robot. For details, refer to the following manual. *EPSON RC+ 7.0 SPEL+ Language Reference* *TCPSpeed Function* Note: Differ from TCPSpeed function, it is measured during PTP motion.
TCPSpeed(X) to TCPSpeed(Z)	mm/sec	Each axis component of tool tip speed in base coordinate system of the robot.
Joint(J1) to Joint(J6)	deg	Each joint angle of robot. For SCARA robot, Joint # 5 and Joint # 6 are always “0”.

Item	Unit	Description	
OLRate(J1) to OLRate(J6)	–	Overload rate of each joint of robot. For details, refer to the following manual *EPSON RC+ 7.0 SPEL+ Language Reference* *OLRate* For SCARA robot, Joint # 5 and Joint # 6 are always "0".	
FCOn	–	Execution state of force control function of robot. The following information is recorded: 1: When executing force control function 0: When the force control function is not executed	
StepID	–	Value specified to the StepID property.	
Seq No	–	Number of a sequence executed by force guide sequence.	
Object No	–	Number of an object executed by force guide sequence.	
Time	–	Time when the data is measured. Displayed in a format of "yyyy/mm/dd hh:mm:ss:ms".	
EndTime	–	Time when the measurement ends. Displayed in a format of "yyyy/mm/dd hh:mm:ss:ms"	
EndCondition	–	Reason for ending measurement. Display as follows depending on each state:	
		Specified measurement time is elapsed (In force monitor, when 600 seconds are elapsing.)	Duration elapsed
		Stop command for recording was executed before the measurement time is elapsed.	End executed property
		Stop force monitor before the measurement time is elapsed.	Stop requested
		Build or rebuild the SPEL program during recording.	Build executed
		Project ends without executing stop command for recording.	Task ended
		An error occurs during recording.	Error occurred
ErrorNo	–	Error number. It is recorded when an error occurs and measurement ends.	
ErrorMessage	–	Error message. It is recorded when an error occurs and measurement ends.	

Usage Example

This is an example of starting the logging of data for sensor 1 (at a frequency of 100 msec for 1 minute) and then ending the logging thereof.

```
Function Test_Record
    FSet FM1.ForceSensor, 1
    FSet FM1.RecordStart, 60, 0.1
      …
    FSet FM1.RecordEnd
Fend
```

Acquisition examples are as follows:

Start Time, File Type, File Version, Channel, Mode, Duration[sec], Interval[sec], Robot No, Robot Name, Sensor No, Sensor Serial, Sensor Label, FM No., FM Label, FCS No., FCS Label, Seq No, Seq Name, RobotLocal

2018/03/15 13:42:54:261, Motion, 1, 1, 1, 60, 0.1, 1, rb001, 1, AAAAA00001, VirtualSensor1, 1, fm001, 1, fcs001, 0, (empty), 0

ElapsedTime[msec], Fx_Force[N], Fy_Force[N], Fz_Force[N], Tx_Force[N·mm], Ty_Force[N·mm], Tz_Force[N·mm], Fmag_Force[N], Tmag_Force[N·mm], CurPos(X)[mm], CurPos(Y)[mm], CurPos(Z)[mm], CurPos(U)[deg], CurPos(V)[deg], CurPos(W)[deg], RefPos(X)[mm], RefPos(Y)[mm], RefPos(Z)[mm], RefPos(U)[deg], RefPos(V)[deg], RefPos(W)[deg], Diff(X)[mm], Diff(Y)[mm], Diff(Z)[mm], TCPSpeed[mm/sec], TCPSpeed(X)[mm/sec], TCPSpeed(Y)[mm/sec], TCPSpeed(Z)[mm/sec], Joint(J1)[deg], Joint(J2)[deg], Joint(J3)[deg], Joint(J4)[deg], Joint(J5)[deg], Joint(J6)[deg], OLRate(J1), OLRate(J2), OLRate(J3), OLRate(J4), OLRate(J5), OLRate(J6), FCOn, StepID, Seq No, Object No, Time

0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 565, 720, 0, -90, -90, 0, 565, 720, 0, -90, -90, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 2018/03/15 13:42:54:261

100, 0, 0, 0, 0, 0, 0, 0, 0, 0, 565, 720, 0, -90, -90, 0, 565, 720, 0, -90, -90, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 2018/03/15 13:42:54:361

(After displaying the above, the actual values will be displayed subsequently.)

Reference

Force Monitor Object FM#

RefPos Status

Application

Robot Object Robot

Comments

This returns the command-position, with force control, for the first variable. For the second variable, the command-position, which reflects only the position control without the effects of force control, is returned.

Usage

FGet Robot.**RefPos**, *Point1, Point2*

Point1 A variable defining the point data

Point2 A variable defining the point data

Detailed Explanation

This returns the command position reflecting the position control-command position and the effects of force control.

The position control command-position defines the virtual path that the original motion command tries to follow.

The force control command-position defines the actual robot path of movement, which is the calculated path reflecting the effect of force control on the position control command-position.

By looking at the amount of difference between the two command values, you see how much the movement is veered from the original path. This is effective when checking to see if the path differs from the original path more than was expected, or to analyze movement tendencies.

Usage Example

This detects if, by force control, the movement has veered beyond a certain amount from the original path, and stops the robot.

```
Function RefPosTest

     FSet FCS1.Orientation, FG_TOOL        ' Sets force coordinate data

     FSet FC1.CoordinateSystem, FCS1       ' Specifies the force coordinate data
     FSet FC1.Fx_Spring, 0                 ' Sets the virtual Fx coefficient of
elasticity
     FSet FC1.Fx_Damper, 1                 ' Sets the virtual Fx coefficient of
viscosity
     FSet FC1.Fx_Mass, 10                  ' Sets the virtual Fx coefficient of inertia
     FSet FC1.Fx_Enabled, True             ' Sets the Fx force control to active
     Xqt RefPosCheck                       ' Launches a separate task to monitor
     Move P0 FC1                           ' A Move motion with force control
     Quit RefPosCheck                      ' Ends the separate monitored task

 Fend

Function RefPosCheck
     Do
          FGet Robot.RefPos, P1, P2       ' Acquires RefPos
          If Abs(CX(P1) - CX(P2)) 50 Then' Checks to see if the difference is 50 or
greater
               Print "Err"                ' An error occurs if the difference is too large
               AbortMotion All            ' Stops motion
          EndIf
          Wait 0.1
     Loop
 Fend
```

Reference

Robot Object Robot

Reset Property

Application

Force Sensor Object FS#

Comments

Resets the force sensor.

Immediate Execution

Yes

Usage

FSet Object.**Reset**

FSet Object.**Reset,** *iValue*

FSet Object.**Reset,** *iValue, rValueTime, rValueThreshF, rValueThreshT*

Object	Object name, or string variable defining the object name The object is specified as FS (numerical value).
iValue	An integer value or formula defining the new value of the property
rValueTime	A real number or formula defining the new value of the property
rValueThreshF	A real number or formula defining the new value of the property
rValueThreshT	A real number or formula defining the new value of the property

Values

iValue

Name of Constants	Values	Description
FG_RESET_FINE	0 (default)	Wait until the robot which the force sensor is connected satisfies Fine condition, and then reset the force sensor.
FG_RESET_WAIT_VIBRATION	1	Wait until the external vibration stops, and then reset the force sensor.

rValueTime

	Value
Minimum	3
Maximum	20

Default: 2.5
(Only when rValueTime is omitted. When specifying the value, be sure to specify the value greater than 3)

rValueThreshF

	Value
Minimum	5
Maximum	20

Default: 5

rValueThreshT

	Value
Minimum	50
Maximum	200

Default: 50

Detailed Explanation

When the Reset Property is executed, the force sensor is reset. Epson's force sensors have a drift characteristic. Reset the force sensor each time right before using the force function.

When iValue is omitted or FG_RESET_FINE is specified, the program waits up to 1.5 seconds until the robot which the force sensor is connected satisfies Fine condition, and then reset the force sensor. When an error occurs since FG_RESET_FINE is specified, specify FG_RESET_WAIT_VIBRATION for iValue. The error may be avoided.
Fine condition is a positioning condition for each joint when the motion ends. In this property, always use a robot 's specific number. The value specifeid by the Fine statement or FineDist statement is not be used for the determination.
When FG_RESET_WAIT_VIBRATION is specified for iValue, the program waits until the external vibration stops, and then reset the force sensor. It may take time to reset the force sensor depending on the state of external vibration.
Maximum wait time until the vibration stops is normally 2.5 seconds, however, it can be specified with rValueTime. You can specify the threshold used to determine that the vibrations have been stoped : the force (Fx,Fy,Fz) can specified by rValueThreshF and the torque (Tx,Ty,Tz) by rValueThreshT.
rValueThreshF and rValueThreshT are peak to peak value. However, if making the threshold larger , zero point of the sensor changes and the accuracy may decrease. Adjust the threshold within the range which is allowable for your task.
rValueTime, rValueThreshF, and rValueThreshT are available only when FG_RESET_WAIT_VIBRATION is specified for iValue.

 CAUTION	■ Be sure to reset the Force Sensor with no external force applied to it. If it is reset with an external force applied to it, the state in which an external force applied is "0". Therefore, if the force applied is removed, the Force Sensor detects a force even if no force is applied. If the force control function is performed in this state, the robot may move unintentionally. Caution is required in this regard.

Usage Example

This is an example of resetting the sensor.

```
> FSet FS1.Reset
> FSet FS1.Reset, FG_RESET_FINE
> FSet FS1.Reset, FG_RESET_WAIT_VIBRATION
```

Reference

Force Sensor Object FS#

RobotLocal Property

Application

Force monitor object FM#

Comments

Sets or returns the local coordinate system that will serve as the basis for robot positions recorded by the force monitor function.

Immediate Execution

No

Usage

FGet Object.**RobotLocal,** *iVar*

FSet Object.**RobotLocal,** *iValue*

Object	Object name or string variable representing object name Object is specified as either of FM (numerical value) or FM (label).
iVar	An integer variable defining the value of the property
iValue	An integer value or formula defining the new value of the property

Values

iValue

	Value
Minimum	0
Maximum	15

Default: 0

Detailed Explanation

This property is used when setting or checking the local coordinate system that will serve as the basis for robot positions to be recorded.

This property changes the basis used to find robot positions/orientations that will be recorded by the RecordStart property or FCMStart property. When “0” is specified, the position/orientation in the Base coordinate system will be recorded.

The position/orientation of the robot recorded by the RecordStart property or FCMStart property is recorded by the position/orientation of the tool specified by the RobotTool property in the local coordinate system specified by this property.

It is effective when, for instance, you wish to record positions/orientations based on a workpiece, or when the work reference plane is tilted.

If the coordinate system is changed by the Base, Local, or other statement after this property is set, the coordinate system used with the force function will apply rather than the coordinate system used when this property was set.

Usage Example

The following is an example of recording positions with Local 1 as the basis.

```
Function RobotLocalTest
    FSet FM1.ForceSensor, 1
    FSet FM1.RobotLocal, 1        ' Set Local 1 for RobotLocal.
    FSet FM1.FCMEnd
    FSet FM1.RecordStart, 60, 0.01
    Wait 60
    FSet FM1.FCMEnd
Fend
```

Reference

Force monitor object FM#, RecordStart Property, FCMStart Property

RobotTool Property

Application

Force monitor object FM#

Comments

Sets or returns the tool that will serve as the basis for robot positions recorded by the force monitor function.

Immediate Execution

No

Usage

FGet Object.**RobotTool,** *iVar*

FSet Object.**RobotTool,** *iValue*

Object	Object name or string variable representing object name Object is specified as either of FM (numerical value) or FM (label).
iVar	An integer variable defining the value of the property
iValue	An integer value or formula defining the new value of the property

Values

iValue

	Value
Minimum	−1 (Constant name: FG_CURRENT_TOOL)
Maximum	15

Default: −1

Detailed Explanation

This property is used when setting or checking the tool that will serve as the basis for robot positions to be recorded.

This property changes the basis used to find robot positions/orientations that will be recorded by the RecordStart property or FCMStart property. When "−1" is specified, the position/orientation is recorded with reference to the current tool. Therefore, when the tool number is changed by the Tool statement during recording, the position/orientation to be recorded will correspond to the changed tool. When a number from "0" to "15" is specified, the position/orientation will continue as per the tool specified.

The position/orientation of the robot recorded by the RecordStart property or FCMStart property is recorded by the position/orientation of the tool specified by this property in the local coordinate system specified by the RobotLocal property.

This property is effective when you want to set the recording position as the specified tool position. When setting "−1", position seems like shifting if changing the tool. Therefore, use each tool number to check continuity.

If the tool setting is changed by the TLSet statement after this property is set, the tool setting used with the force function will apply rather than the tool setting used when this property was set.

Usage Example

The following is an example of recording positions with Tool 1 as the basis.

```
Function RobotLocalTest
    FSet FM1.ForceSensor, 1
    FSet FM1.RobotTool, 1     ' Set Tool 1 for RobotTool.
    FSet FM1.FCMEnd
    FSet FM1.RecordStart, 60, 0.01
    Wait 60
    FSet FM1.FCMEnd
Fend
```

Reference

Force monitor object FM#, RecordStart Property, FCMStart Property

SerialCode Property

Application

Force Sensor Object FS#

Comments

Returns the serial code for the force sensor.

Immediate Execution

No

Usage

FGet Object**.SerialCode,** *sVar$*

Object Object name, or string variable defining the object name
The object is specified as FS (numerical value).

sVar$ A string variable defining the value of the property

Detailed Explanation

This property is used to confirm the sensor's serial code

Usage Example

This is an example of confirming the Force Sensor Object's serial code.

```
Function Test_SerialCode
    String serialcode$
    FGet FS1.SerialCode, serialcode$
    Print serialcode$
Fend
```

Reference

Force Sensor Object FS#

StepID Property

Application

Robot Object Robot

Comments

This sets or returns the step number and step label so the user understands the task or job progression situation.
The step label can be omitted and it is possible to set and return only the step number.

Immediate Execution

No

Usage

FGet *Object*.**StepID**, *iVar*

FGet *Object*.**StepID**, *iVar, sVar$*

FSet *Object*.**StepID**, *iValue*

FSet *Object*.**StepID**, *iValue, sValue$*

Object	Object name, or string variable defining the object name
iVar	An integer variable
iValue	An integer or formula defining the new value
sVar$	A string variable
sValue$	An string or formula defining the new value

Values

iValue

	Values
Minimum	0 (default)
Maximum	32767

sValue$

Up to 32 one-byte or 16 two-byte alphanumeric characters, Japanese characters, and the underscores can be used.

Detailed Explanation

This property is used to set or confirm the StepID and step label the task or job progression situation is understood.

Usage Example

This example sets and confirms the StepID in order to confirm the progress of the main process.

(Step label is omitted.)

```
Function Test_SetStepID(iStepID As Integer)  ' Process to set StepID
    FSet Robot.StepID, iStepID
Fend

Function Test_GetStepID        ' Process to acquire the StepID
    Integer iStepID
    FGet Robot.StepID, iStepID
    Print iStepID
Fend

Function Test_Main             ' Main process executing the force control function
    ...
    Move P0 FC1 CF
    Test_SetStepID(1)          ' Setting StepID=1
    ...
    Move P1 FC2 CF
    Test_SetStepID(2)          ' Setting StepID=2
    ...
    FSet FS1.Reset
    Test_SetStepID(3)          ' Setting StepID=3
    ...
    Move P3 FC3 CF
    Test_SetStepID(4)          ' Setting StepID=4
    ...
Fend

Function Test_Sub              ' Sub-process which monitors at 5 second intervals
    Do
        Test_GetStepID
        Wait(5)
    Loop
Fend
```

Reference

Robot Object Robot

TargetForcePriorityMode Property

Application

Force Control Object FC#

Comments

Activates/inactivates or returns the status thereof the target force priority mode.

Immediate Execution

No

Usage

FGet Object.TargetForcePriorityMode, b*Var*

FSet Object.TargetForcePriorityMode, b*Value*

Object Object name, or string variable defining the object name
The object is specified as either of FC (numerical value) or FC (label).

bVar A Boolean variable defining the value of the property

bValue A Boolean value or formula defining the new value of the property

Values

bValue

Name of Constants	Values	Description
False	0	Inactivates the target force priority mode. (default)
True	–1	Activates the target force priority mode.

Detailed Explanation

There are times when the target force or target torque is set and the force control function is used that the target force is not achieved even after sufficient time. In such instances, activate the TargetForcePriorityMode when wanting to accurately match the target force. However, when the TargetForcePriorityMode is activated, operation of the robot will not be in accordance with the established values for the following coefficients, and the motion may be slowed at times.

Virtual coefficients of elasticity (Spring)
Virtual coefficients of viscosity (Damper)
Virtual coefficients of inertia (Mass)

Usage Example

This example activates the target priority mode and uses the force control function.

```
Function ForceControlTest
   FSet FCS1.Orientation, FG_TOOL
   FSet FC1.CoordinateSystem, FCS1
   FSet FC1.Enabled, False, False, True, False, False, False
   FSet FC1.Fz, 0.01, 4, 5
   FSet FC1.Fz_TargetForce, 10
   FSet FC1.TargetForcePriorityMode, True
   FCKeep FC1, 5
Fend
```

Reference

Force Control Object FC#

TargetForces Property

Application

Force Control Object FC#

Comments

This sets or returns the value of target force and torque for each of the 6 axes in the force coordinate system at the same time.

Immediate Execution

No

Usage

FGet Object.TargetForces, r*Array()*

FSet Object.TargetForces, r*ValueFx*, r*ValueFy*, r*ValueFz*, r*ValueTx*, r*ValueTy*, r*ValueTz*

Object Object name, or string variable defining the object name
The object is specified as either of FC (numerical value) or FC (label).

rArray() The number of elements defining the value of the property is an array of 6 or more real numbers

rValueFx A real number or formula defining the new value of the property

rValueFy A real number or formula defining the new value of the property

rValueFz A real number or formula defining the new value of the property

rValueTx A real number or formula defining the new value of the property

rValueTy A real number or formula defining the new value of the property

rValueTz A real number or formula defining the new value of the property

Values

rArray()

Element number	Element number constant	Description
0	FG_FX	Fx target force
1	FG_FY	Fy target force
2	FG_FZ	Fz target force
3	FG_TX	Tx target torque
4	FG_TY	Ty target torque
5	FG_TZ	Tz target torque

rValueFx, rValueFy, rValueFz (Unit: [N])

	Values
Minimum	The rated negative detection capability of the force sensor
Maximum	The rated positive detection capability of the force sensor

Default: 0

rValueTx, rValueTy, rValueTz (Unit: [N·mm])

	Values
Minimum	The negative rated torque detection capability of the force sensor
Maximum	The positive rated torque detection capability of the force sensor

Default: 0

Detailed Explanation

This returns the value of or sets the target force and torque for the force control function for the 6 axes at the same time.

It sets the following target forces and torques.

rValueFx: Fx rValueFy: Fy rValueFz: Fz

rValueTx: Tx rValueTy: Ty rValueTz: Tz

When the force control function is executed with the target force or torque being set to “0”, the robot moves so that the force becomes “0” and operates while following the external force. Since the axes are independent each other, the robot can follow the force in Fx and Fy directions while pressing in the Fz direction.

When using the force control function having set the target force and torque, there are times that the target force is not achieved even after sufficient time. In such instances, activate the TargetForcePriorityMode when wanting to accurately match the target force.

However, when the TargetForcePriorityMode is activated, operation of the robot will not be in accordance with the established values for the virtual coefficients of elasticity, viscosity, and inertia, and the motion may be slowed at times.

Usage Example

This example sets the target force and uses the force control function.

```
Function ForceControlTest
   FSet FCS1.Orientation, FG_TOOL
   FSet FC1.CoordinateSystem, FCS1
   FSet FC1.Enabled, False, True, True, False, False, False
   FSet FC1.Fy, 0.01, 4, 5
   FSet FC1.Fz, 0.01, 4, 5
   FSet FC1.TargetForces, 0, 10, -10, 0, 0, 0
   FCKeep FC1, 5
Fend
```

Reference

Force Control Object FC#,
Fx_TargetForce, Fy_TargetForce, Fz_TargetForce,
Tx_TargetForce, Ty_TargetForce, Tz_TargetForce Property

Time Result

Comments

Returns execution time for a force guide sequence or force guide object.

Usage

FGGet *Sequence*.**Time**, *rVar*

FGGet *Sequence*.*Object*.**Time**, *rVar*

Sequence	Force guide sequence name or string variable representing force guide sequence name
Object	Force guide object name or string variable representing force guide object name. Omitted when a result of a force guide sequence is acquired.
rVar	Real variable that shows a returned value

Detailed Explanation

Returns execution time for a force guide sequence or force guide object.

Usage Example

The following is an example of a simple program that acquires a result with FGGet.

```
Function TimeTest
     Real rVar
     Motor On

     FGRun Sequence1
     FGGet Sequence1.Contact01.Time, rVar     ' Acquisition of Time
     Print rVar

 Fend
```

Reference

FGGet, force guide sequence, Contact object, Relax object, FollowMove object, SurfaceAlign object, PressProbe object, ContactProbe object, Press object, PressMove object ,SPELfunc object

Tmag_AvgForce Status

Application

Force Monitor Object FM#

Comments

This returns the average value of the resultant torque.

Usage

FGet Object.**Tmag_AvgForce,** r*Var*

Object Object name, or string variable defining the object name
The object is specified as FM (numerical value) or FM (label).

rVar A real number variable defining the value of the property

Detailed Explanation

Tmag_AvgForce returns the average value of the resultant torque.

Before executing Tmag_AvgForce, be sure to execute AvgForceClear. If AvgForceClear is not executed, "0" is returned.

When the time from executing AvgForceClear to executing Tmag_AvgForce is short, a deviation in the average force and torque is generated. When LowPassFilter is used, set the time about 5 times the LowPassFilter time constant between AvgForceClear and Tmag_AvgForce execution.

There is a time limit on Tmag_AvgForce. Execute Tmag_AvgForce within 600 seconds of executing AvgForceClear. When Tmag_AvgForce is executed after 600 seconds has passed, an error is generated.

Usage Example

This example measures the average value of the resultant torque.

```
Function CheckAverageForce
   Double AF
   FSet FC1.Enabled, False, False, False, True, False, False
   FSet FC1.TargetForces, 0, 0, 0, 200, 0, 0
   FSet FS1.Reset
   FSet FM1.CoordinateSystem, FCS0
   FSet FM1.AvgForceClear, False, False, False, False, False, False, False,
True
   FCKeep FC1, 10
   FGet FM1.Tmag_AvgForce, AF
   Print AF
Fend
```

Reference

Force Monitor Object FM#

Tmag_Axes Property

Application

Force Trigger Object FT#, Force Monitor Object FM#

Comments

Sets or returns the subject axis for calculating the resultant torque.

Immediate Execution

No

Usage

FGet Object.**Tmag_Axes,** *iVar*

FSet Object.**Tmag_Axes,** *iValue*

Object Object name, or string variable defining the object name
The object is specified as FT (numerical value), FT (label), FM (numerical value), or FM (label).

iVar An integer variable defining the value of the property

iValue An integer value or formula defining the new value of the property

Values

iValue (Unit: Number)

Name of Constants	Values	Description
FG_XYZ	0	Defines as resultant torque for XYZ axes (default) (Tmag = sqrt($Tx^2 + Ty^2 + Tz^2$))
FG_XY	1	Defines as resultant torque for XY axes. (Tmag = sqrt($Tx^2 + Ty^2$))
FG_YZ	2	Defines as resultant torque for YZ axes. (Tmag = sqrt($Ty^2 + Tz^2$))
FG_ZX	3	Defines as resultant torque for ZX axes. (Tmag = sqrt($Tx^2 + Tz^2$))

Detailed Explanation

Tmag is the resultant force from the subject axes selected from X, Y, and Z axes.

This property is used when setting or checking the subject axes to obtain the resultant torque with respect to the Force Trigger Object and Force Monitor Object.

Usage Example

This example sets and acquires the axes wherein the resultant force will be applied for the Force Monitor Object.

```
Function Test_Tmag_Axes
    Integer iVar
    FSet FM1.Tmag_Axes, FG_ZX
    FGet FM1.Tmag_Axes, iVar
    Print iVar
Fend
```

Reference

Force Trigger Object FT#, Force Monitor Object FM#

Tmag_Enabled Property

Application

Force Trigger Object FT#

Comments

Activates/inactivates the trigger based on Tmag resultant torque.

Immediate Execution

No

Usage

FGet Object.Tmag_Enabled, b*Var*

FSet Object.Tmag_Enabled, b*Value*

Object	Object name, or string variable defining the object name The object is specified as either of FT (numerical value) or FT (label).
b*Var*	A Boolean variable defining the value of the property
b*Value*	A Boolean value or formula defining the new value of the property

Values

bValue

Name of Constants	Values	Description
False	0	Inactivates the subject axis. (default)
True	–1	Activates the subject axis.

Detailed Explanation

Activates/inactivates the trigger based on Tmag resultant torque.

Usage Example

This example activates the Tmag resultant torque trigger for the Force Trigger Object.

```
> FSet FT1.Tmag_Enabled, True
```

Reference

Force Trigger Object FT#

Tmag_Force Status

Application

Force Monitor Object FM#

Comments

This returns the resultant torque.

Usage

FGet Object.**Tmag_Force,** *rVar*

Object	Object name or string variable defining object name The object is specified as either of FM (numerical value) or FM (label).
rVar	A real number variable defining the value of the property

Detailed Explanation

Tmag_Force returns the resultant torque for the subject axes specified in Tmag_Axes in the force coordinate system specified by the CoordinateSystem.

Usage Example

This example acquires the resultant torque in the X and Y axes within the specified force coordinate system.

```
Function Test_Tmag_Force
    Real rVar
    FSet FCS1.Position, 0, 0, 100
    FCS1.Orientation, FG_TOOL
    FSet FM1.ForceSensor, 1
    FSet FM1.CoordinateSystem, FCS1
    FSet FM1.Tmag_Axes, FG_XY
    FGet FM1.Tmag_Force, rVar
    Print rVar
Fend
```

Reference

Force Monitor Object FM#

Tmag_Levels Property

Application

Force Trigger Object FT#

Comments

Sets or returns the upper and lower threshold values for resultant torque.

Immediate Execution

No

Usage

FGet Object.**Tmag_Levels,** r*Array()*

FSet Object.**Tmag_Levels,** *rValueL, rValueU*

Object Object name, or string variable defining the object name
The object is specified as either of FT (numerical value) or FT (label).

rArray The number of elements defining the values of the property is an array of 2 or more real number variables

rValueL A real number or formula defining the new value of the property.

rValueU A real number or formula defining the new value of the property.

Values

rArray()

Element number	Element number constant
0	FG_LOWERLEVEL
1	FG_UPPERLEVEL

rValueL (Unit: [N·mm])

	Values
Minimum	0 (default)
Maximum	100000

rValueU (Unit: [N·mm])

	Values
Minimum	0
Maximum	100000 (default)

Detailed Explanation

Tmag_Levels sets or returns the value of the lower and upper thresholds for resultant torque.

rValueL is the lower threshold. rValueU is the upper threshold. Be sure that rValueL < rValueU.

This is used for error checking and task completion conditions.

Usage Example

This example generates an error and stops the robot if the resultant torque is lower than the lower threshold or higher than the upper threshold.

```
Function SettingLevels
     FSet FT1.Enabled, False, False, False, False, False, False, False,
True
     FSet FT1.Tmag_Polarity, FG_OUT
     FSet FT1.Tmag_Levels, 0, 3000
     Trap 1, FT1 Call ForceError
 Fend

 Function ForceError
     AbortMotion All
 Fend
```

Reference

Force Trigger Object FT#

Tmag_LPF_Enabled Property

Application

Force Trigger Object FT#, Force Monitor Object FM#

Comments

Activates/inactivates or returns the resultant torque low-pass filter.

Immediate Execution

No

Usage

FGet Object.Tmag_LPF_Enabled, bV*ar*

FSet Object. Tmag_LPF_Enabled, bV*alue*

Object Object name, or string variable defining the object name
The object is specified as FT (numerical value), FT (label), FM (numerical value), or FM (label).

bV*ar* A Boolean variable defining the value of the property

bV*alue* A Boolean value or formula defining the new value of the property

Values

bValue

Name of Constants	Values	Description
False	0	Sets the low-pass filter to inactive. (default)
True	–1	Sets the low-pass filter to active.

Detailed Explanation

This activates/inactivates or returns the status of the resultant torque low-pass filter.

When the low-pass filter is active, signal noise can be reduced, but the following performance for quick signal changes deteriorates.

The low-pass filter is used with AvgForces Status, PeakForces Status, the Force Trigger Function, and Force Monitor, but is not used with Forces Status.

Usage Example

This example sets the resultant torque low-pass filter, and acquires the absolute value of the peak resultant torque.

```
Function GetPeakForceTest
     Real myPeakForce
     FSet FCS1.Orientation, FG_TOOL
     FSet FM1.CoordinateSystem, FCS1
     FSet FM1.Tmag_Axes, FG_XYZ
     FSet FM1.Tmag_LPF_Enabled, True
     FSet FM1.Tmag_LPF_TimeConstant, 0.02
     FSet FM1.PeakForceClear, True, True, True, True, True, True, True,
True
     Wait 10
     FGet FM1.Tmag_PeakForce, myPeakForce
     Print myPeakForce
Fend
```

Reference

Force Trigger Object FT#, Force Monitor Object FM#

Tmag_LPF_TimeConstant Property

Application

Force Trigger Object FT#, Force Monitor Object FM#

Comments

This sets or returns the value of the time constant for the low-pass filter applied to resultant torque.

Immediate Execution

No

Usage

FGet Object.**Tmag_LPF_TimeConstant**, *rVar*

FSet Object.**Tmag_LPF_TimeConstant**, *rValue*

Object Object name, or string variable defining the object name
The object is specified as FT (numerical value), FT (label), FM (numerical value), or FM (label).

rVar A real number variable defining the value of the property

rValue A real number or formula defining the new value of the property

Values

rValue (Unit: [sec])

	Values
Minimum	0.002
Maximum	5

Default: 0.01

Detailed Explanation

This sets the time constant for the resultant torque low-pass filter.

The low-pass filter time constant is the time it takes to arrive at an input value of $1\text{-}e^{-1}$ (approximately 63.2%) when giving step input.

The signal noise reduction can be enhanced when increasing the time constant, but the following performance for quick signal changes deteriorates.

The low-pass filter is used with AvgForces Status, PeakForces Status, the Force Trigger Function, and Force Monitor, but is not used with Forces Status.

Usage Example

This example sets the resultant torque low-pass filter, and acquires the absolute value of the peak resultant torque.

```
Function GetPeakForceTest
     Real myPeakForce
     FSet FCS1.Orientation, FG_TOOL
     FSet FM1.CoordinateSystem, FCS1
     FSet FM1.Tmag_Axes, FG_XYZ
     FSet FM1.Tmag_LPF_Enabled, True
     FSet FM1.Tmag_LPF_TimeConstant, 0.02
     FSet FM1.PeakForceClear, True, True, True, True, True, True, True,
True
     Wait 10
     FGet FM1.Tmag_PeakForce, myPeakForce
     Print myPeakForce
 Fend
```

Reference

Force Trigger Object FT#, Force Monitor Object FM#

Tmag_PeakForce Status

Application

Force Monitor Object FM#

Comments

Returns the resultant torque peak.

Usage

FGet *Object*.**Tmag_PeakForce**, *rVar*

Object Object name or string variable defining object name
The object is specified as either of FM (numerical value) or FM (label).

rVar A real number variable defining the value of the property

Detailed Explanation

Tmag_PeakForce returns the value of peak resultant torque.

Before executing Tmag_PeakForce, execute PeakForceClear.

Usage Example

This example measures the value of the peak resultant torque.

```
Function CheckPeakForce
   Double PF
   FSet FC1.Enabled, False, False, False, True, False, False
   FSet FC1.TargetForces, 0, 0, 0, 200, 0, 0
   FSet FS1.Reset
   FSet FM1.CoordinateSystem, FCS0
   FSet FM1.PeakForceClear, False, False, False, False, False, False, False,
True
   FCKeep FC1, 10
   FGet FM1.Tmag_PeakForce, PF
   Print PF
Fend
```

Reference

Force Monitor Object FM#

Tmag_Polarity Property

Application

Force Trigger Object FT#

Comments

Sets or returns for resultant torque whether the force trigger is activated or inactivated when values correspond to or do not correspond with threshold values.

Immediate Execution

No

Usage

FGet Object.***Tmag_*Polarity**, *iVar*

FSet Object.***Tmag_*Polarity**, *iValue*

Object Object name, or string variable defining the object name
The object is specified as either of FT (numerical value) or FT (label).

iVar An integer variable defining the value of the property

iValue An integer value or formula defining the new value of the property

Values

iValue

Name of Constants	Values	Description
FG_OUT	0	Activates when the value is outside of the thresholds. (default)
FG_IN	1	Activates when the value is within the thresholds.

Detailed Explanation

Tmag_Polarity returns the status of or sets whether the force trigger is triggered by the value of the resultant torque being either within the thresholds or outside of the thresholds.

Usage Example

This example generates an error and stops the robot when the resultant torque is greater than the upper threshold or lower than the lower threshold.

```
Function SettingPolarity
   FSet FT1.Enabled, False, False, False, False, False, False, False,
True
   FSet FT1.Tmag_Polarity, FG_OUT
   FSet FT1.Tmag_Levels, 0, 3000
   Trap 1, FT1 Call ForceError
Fend

Function ForceError
     AbortMotion All
Fend
```

Reference

Force Trigger Object FT#

TMove Statement

Comments

Executes an offset linear interpolation motion in the current tool coordinate system with the force control function active.

Usage

TMove *P#* [*FC#*] [ROT] [CP] [CF] [Till | Find] [! parallel processing!] [SYNC]

P# Specifies the point data defining the target position of the motion.

FC# Specifies the force control object.

CF Continues the force control function. Can be omitted.

Detailed Explanation

By adding a force control object as a parameter to an ordinary TMove command, a TMove motion is executed with the control force function active.

For TMove motion details, refer to the following manual.
EPSON RC+ 7.0 SPEL+ Language Reference
TMove

For details on the force control function refer to *Move Statement*.

Usage Example

This is a simple program example to execute a TMove motion with the force control active.

In this example, a TMove motion is executed with the force control function active in the X axis direction of the tool coordinate system.

```
Function ForceTMoveTest
    FSet FCS1.Orientation, FG_TOOL      ' Sets the force coordinate data

    FSet FC1.CoordinateSystem, FCS1     ' Specifies the force coordinate data
    FSet FC1.Fx_Spring, 0               ' Sets virtual Fx coefficient of elasticity
    FSet FC1.Fx_Damper, 1               ' Sets virtual Fx coefficient of viscosity
    FSet FC1.Fx_Mass, 10                ' Sets virtual Fx coefficient of inertia
    FSet FC1.Fx_Enabled, True           ' Sets the Fx force control function to active

    TMove XY(100,0,0,0) FC1             ' Executes a TMove motion with the force
                                        ' control function active
Fend
```

Reference

TMove, Move, Force Control Object FC#

Triggered Status

Application

Force Trigger Object FT#

Comments

This returns the status/condition of the force trigger.

Immediate Execution

No

Usage

FGet Object.***Triggered***, *bVar*

Object Object name, or string variable defining the object name
The object is specified as either of FT (numerical value) or FT (label).

bVar A Boolean variable defining the value of the property

Detailed Explanation

This returns the status/condition just prior to the triggering of the force trigger. When the force trigger conditions are met, “True” is returned. “False” is returned when not met.
This is used for branch processing when force is used as a condition.

Usage Example

This example branches the process due to meeting the force trigger conditions.

```
Function TriggeredTest
    Boolean bVar
    FCKeep FC1 Till FT1, 10
    FGet FT1.Triggered, bVar
    If bVar = True Then
        'The process when the trigger conditions are met
          -
    Else
        'The process when the trigger conditions are not met
           -
    EndIf
Fend
```

Reference

Force Trigger Object FT#

TriggeredAxes Status

Application

Force Trigger Object FT#

Comments

This returns the met/not met status of the force trigger by axis.

Immediate Execution

No

Usage

FGet Object.***TriggeredAxes***, *iVar*

Object Object name, or string variable defining the object name
The object is specified as either of FT (numerical value) or FT (label).

iVar An integer variable defining the value of the property

Values

Bit	Results
0	Met Fx LowerLevel conditions
1	Met Fy LowerLevel conditions
2	Met Fz LowerLevel conditions
3	Met Tx LowerLevel conditions
4	Met Ty LowerLevel conditions
5	Met Tz LowerLevel conditions
6	Met Fmag LowerLevel conditions
7	Met Tmag LowerLevel conditions
8	Met Fx UpperLevel conditions
9	Met Fy UpperLevel conditions
10	Met Fz UpperLevel conditions
11	Met Tx UpperLevel conditions
12	Met Ty UpperLevel conditions
13	Met Tz UpperLevel conditions
14	Met Fmag UpperLevel conditions
15	Met Tmag UpperLevel conditions

The value of each Bit

0: Not met

1: Met

Detailed Explanation

This returns the met/not met status by axis for the force trigger just before triggering.
For each axis of the force trigger, the corresponding bit is “1” when the conditions are met. The bit is “0” when not met.
However, when under the Polarity Property FG_OUT is set, the UpperLevel and LowerLevel are set to “1” or “0”.
When FG_IN is set, both the UpperLevel and LowerLevel are set to “1” when the conditions are met.
This is used to accomplish branch processing based on the met/not met status of force in each axis.
When a value is acquired for an Integer variable, depending on the met/not met status, there are times when the value is negative. Int32 or Int64 type variables are recommended.

Usage Example

This is an example of branch processing based on the met/not met status of each axis for the force trigger.

```
Function TriggeredAxesTest
    Int64 iVar
    FCKeep FC1 Till FT1, 10
    FGet FT1.TriggeredAxes, iVar
    If (iVar And &H01) <> 0 Then
        ' The process when Fx LowerLevel conditions are met
            -
            -
            -
    ElseIf (iVar And &H100) <> 0 Then
        ' The process when Fx UpperLevel conditions are met
            -
            -
            -

    EndIf
Fend
```

Reference

Force Trigger Object FT#

TriggeredForces Status

Application

Force trigger object FT#

Comments

Returns force and torque applied when force trigger conditions are achieved.

Usage

FGet *Object*.**TriggeredForces**, r*Array()*

Object Object name or string variable representing object name
Object is specified as either of FT (numerical value) or FT (label).

rArray() Real array variable with six or more elements showing values of property

Values

rArray()

Element number	Element number constant	Description
0	FG_FX	Acquires force in Fx direction when force trigger conditions are achieved.
1	FG_FY	Acquires force in Fy direction when force trigger conditions are achieved.
2	FG_FZ	Acquires force in Fz direction when force trigger conditions are achieved.
3	FG_TX	Acquires torque in Tx direction when force trigger conditions are achieved.
4	FG_TY	Acquires torque in Ty direction when force trigger conditions are achieved.
5	FG_TZ	Acquires torque in Tz direction when force trigger conditions are achieved.
6	FG_FMAG	Acquires resultant force Fmag when force trigger conditions are achieved.
7	FG_TMAG	Acquires resultant torque Tmag when force trigger conditions are achieved.

Note: Element numbers of 0 to 5 are acquired when an array variable has six or seven elements.

Detailed Explanation

Returns the force and torque applied when the force trigger conditions are achieved.
Returns “0” for all values when the force trigger conditions are not achieved.
When multiple force triggers are combined as described below, each force trigger object will retain the force and torque that applied when the given force trigger object conditions were first achieved.

Till FT1 And FT2

Therefore, when force trigger objects having different conditions are combined and used, the TriggeredForces status of each force trigger object will differ.

Usage Example

The following is an example of acquiring and displaying the force applied when the force trigger is achieved.

```
Function TriggeredForceTest
    Real rArray(7)
    FCKeep FC1 Till FT1, 10
    FGet FT1.TriggeredForces, rArray()
    Print rArray(FG_FX)
Fend
```

Reference

Force trigger object FT#

TriggeredForces Result

Comments

Returns force and torque for a force guide object when force-related end conditions are achieved.

Usage

FGGet *Sequence*.*Object*.**TriggeredForces**, *rArray()*

Sequence Force guide sequence name or string variable representing force guide sequence name

Object Force guide object name or string variable representing force guide object name.

rArray Real array variable with six or more elements showing returned values

Values

rArray()

Element number	Element number constant	Description
0	FG_FX	Acquires force in Fx direction when force-related end conditions are achieved.
1	FG_FY	Acquires force in Fy direction when force-related end conditions are achieved.
2	FG_FZ	Acquires force in Fz direction when force-related end conditions are achieved.
3	FG_TX	Acquires torque in Tx direction when force-related end conditions are achieved.
4	FG_TY	Acquires torque in Ty direction when force-related end conditions are achieved.
5	FG_TZ	Acquires torque in Tz direction when force-related end conditions are achieved.

Detailed Explanation

Returns force and torque for a force guide object when force-related end conditions are achieved.

Returns “0” for all values when force-related end conditions are not achieved or end conditions are invalid.

If the number of elements in a specified array variable is less than six, returns force and torque in each direction for the defined element numbers. Also, if the number of elements in the array variable exceeds six, returns force and torque in each direction from element number 0 to 5, while making no change to element number 6 and above.

Usage Example

The following is an example of a simple program that acquires a result with FGGet.

```
Function TriggeredForcesTest
    Double dArray(6)

    Motor On

    FGRun Sequence1
    FGGet Sequence1.Contact01.TriggeredForces, dArray()
          ' Acquisition of TriggeredForces
    Print dArray(FG_FX)

 Fend
```

Reference

FGGet, Contact object, Relax object, SurfaceAlign object, PressProbe object, ContactProbe object, Press object, PressMove object

TriggeredPos Status

Application

Force Trigger Object FT#

Comments

This returns the position when the force trigger conditions are met.

Immediate Execution

No

Usage

FGet Object.***TriggeredPos***, *P#*

Object Object name, or string variable defining the object name
The object is specified as either of FT (numerical value) or FT (label).

P# A variable defining the point data

Detailed Explanation

This returns the position just prior to the triggering of the force trigger when the triggering conditions are met.
When the force trigger conditions are not met, a value of "0" is returned for all.
When, as below, multiple force triggers are combined, the position for when that force trigger's conditions were first met is maintained for each Force Trigger Object.

Till FT1 And FT2

Therefore, when Force Trigger Objects with different conditions are used in combination, the TriggeredPos status is different for each Force Trigger Object.

Usage Example

This example acquires and displays the position when the force trigger conditions are met.

```
Function TriggeredPosTest
    FCKeep FC1 Till FT1, 10
    FGet FT1.TriggeredPos, P1
    Print P1
Fend
```

Reference

Force Trigger Object FT#

TriggeredPos Result

Comments

Returns position for a force guide object when force-related end conditions are achieved.

Usage

FGGet *Sequence*.*Object*.**TriggeredPos**, *P#*

Sequence	Force guide sequence name or string variable representing force guide sequence name
Object	Force guide object name or string variable representing force guide object name.
P#	Variable representing a point data

Detailed Explanation

Returns position for a force guide object when force-related end conditions are achieved.

Returns 0 for all values when force-related end conditions are not achieved or end conditions are invalid.

Usage Example

The following is an example of a simple program that acquires a result with FGGet.

```
Function EndPosTest

     Motor On

     FGRun Sequence1
     FGGet Sequence1.Contact01.TriggeredPos, P1     ' Acquisition of TriggeredPos
     Print P1

 Fend
```

Reference

FGGet, Contact object, Relax object, SurfaceAlign object, PressProbe object, ContactProbe object, Press object, PressMove object

TriggerMode Property

Application

Force Trigger Object FT#

Comments

Sets or returns the object of the force trigger monitor.

Immediate Execution

No

Usage

FGet Object.***TriggerMode***, *iVar*

FSet Object.***TriggerMode***, *iValue*

Object Object name, or string variable defining the object name
The object is specified as either of FT (numerical value) or FT (label).

iVar An integer variable defining the value of the property

iValue An integer value or formula defining the new value of the property

Values

iValue

Name of Constants	Values	Description
FG_FORCE	0	Monitor force and torque. (default)
FG_DIFF	1	Monitor change in force and torque.

Detailed Explanation

This sets or returns whether the subject being monitored for the force trigger is force and torque or the change thereof.
When monitoring for force above or below a certain value, FC_FORCE is used. When monitoring for a change in force above or below a certain value, FG_DIFF is used.
Change in force is monitored in terms of [N/sec] and change in the torque is monitored in terms of [N·mm/sec].
When monitoring change, the use of a low-pass filter is recommended as the effects of noise is significant.

Usage Example

This example monitors force. The force control function is activated for 10 seconds if force goes below –3[N] or above 3[N].

```
Function TriggerModeTest_FORCE
    FSet FT1.Fx_Enabled, True
    FSet FT1.Fx_Levels, -3, 3
    FSet FT1.TriggerMode, FG_FORCE

    Till FT1
    FCKeep FC1 Till, 10
Fend
```

This example monitors change in force. The force control function is activated for 10 second if the change goes below –50[N/sec] or above 50[N/sec].

```
Function TriggerModeTest_DIFF
    FSet FT1.Fx_Enabled, True
    FSet FT1.Fx_Levels, -50, 50
    FSet FT1.Fx_LPF_Enabled, True
    FSet FT1.Fx_LPF_TimeConstant, 0.1
    FSet FT1.TriggerMode, FG_DIFF

    Till FT1
    FCKeep FC1 Till, 10
    Print TillOn
Fend
```

Reference

Force Trigger Object FT#

Tx_AvgForce, Ty_AvgForce, Tz_AvgForce Status

Application

Force Monitor Object FM#

Comments

This returns the average torque for the specified axis in the direction of rotation.

Usage

FGet Object.**XX_AvgForce**, *rVar*

Object Object name or string variable defining object name
The object is specified as either of FM (numerical value) or FM (label).

XX A character string defining the name of the property

rVar A real number variable defining the value of the property

Values

XX

Specified Axis	Description
Tx	Specifies X axis in the direction of rotation.
Ty	Specifies Y axis in the direction of rotation.
Tz	Specifies Z axis in the direction of rotation.

Detailed Explanation

XX_AvgForce returns the value of the average torque in the specified axis in the direction of rotation. Execute AvgForceClear before executing XX_AvgForce. Without executing AvgForceClear, 0 is returned.

If the time between executing AvgForceClear and executing XX_AvgForce is short, a deviation in the force and torque averages will occur. Establish a low-pass filter with a time constant of about 5 times between the AvgForceClear and the XX_AvgForce execution.

There is a time limit on AvgForce. Execute Fmag_AvgForce within 600 seconds of executing AvgForceClear. When XX_AvgForce is executed after 600 seconds has passed, an error is generated.

Usage Example

This example measures the value of the average torque in the Tx direction.

```
Function CheckAverageForce
   Double AF
   FSet FC1.Enabled, False, False, False, True, False, False
   FSet FC1.TargetForces, 0, 0, 0, 200, 0, 0
   FSet FS1.Reset
   FSet FM1.CoordinateSystem, FCS0
   FSet FM1.AvgForceClear, False, False, False, True, False,
                           False, False, False
   FCKeep FC1, 10
   FGet FM1.Tx_AvgForce, AF
   Print AF
Fend
```

Reference

Force Monitor Object FM#

Tx_Damper, Ty_Damper, Tz_Damper Property

Application

Force Control Object FC#

Comments

This sets or returns the value of the virtual coefficient of viscosity for force control in the specified axis of the force coordinate system.

Immediate Execution

No

Usage

FGet Object.**XX_Damper**, *rVar*

FSet Object.**XX_Damper**, *rValue*

Object Object name, or string variable defining the object name
The object is specified as either of FC (numerical value) or FC (label).

XX A character string defining the name of the property

rVar A real number variable defining the value of the property

rValue A real number or formula defining the new value of the property

Values

XX

Specified Axis	Description
Tx	Specifies X axis in the direction of rotation.
Ty	Specifies Y axis in the direction of rotation.
Tz	Specifies Z axis in the direction of rotation.

rValue (Unit: [N·mm/(deg/sec)])

	Values
Minimum	10
Maximum	1000000

Default: 3000

Detailed Explanation

This sets or returns the value of the virtual coefficient of viscosity for force control in the direction of rotation for the specified axis of the established force coordinate system.

Refer to the following manual for details on coefficients.

EPSON RC+ 7.0 Option Force Guide 7.0

Usage Example

This example sets the virtual Tx coefficients of elasticity, viscosity, and inertia, and carries out a motion with the force control function active.

```
Function ForceControlTest
    FSet FCS1.Orientation, FG_TOOL
    FSet FC1.CoordinateSystem, FCS1
    FSet FC1.Enabled, False, False, False, True, False, False
    FSet FC1.Tx_Spring, 20000
    FSet FC1.Tx_Damper, 8000
    FSet FC1.Tx_Mass, 10000
    Move CurPos +TLW(10) FC1 ROT
Fend
```

Reference

Force Control Object FC#

Tx_Enabled, Ty_Enabled, Tz_Enabled Property

Application

Force Control Object FC#, Force Trigger Object FT#

Comments

This activates/inactivates, or returns the force control function of the rotational direction.

Immediate Execution

No

Usage

FGet Object.**XX_Enabled**, *bVar*

FSet Object. **XX_Enabled**, *bValue*

Object Object name, or string variable defining the object name

XX A character string defining the name of the property

bVar A Boolean variable defining the value of the property

bValue A Boolean value or formula defining the new value of the property

Values

XX

Specified Axis	Description
Tx	Specifies X axis in the direction of rotation.
Ty	Specifies Y axis in the direction of rotation.
Tz	Specifies Z axis in the direction of rotation.

bValue

Name of Constants	Values	Description
False	0	Inactivates the subject axis. (default)
True	–1	Activates the subject axis.

Detailed Explanation

This activates/inactivates, or returns the force control function of the rotational direction.

For SCARA robots (including RS series), the force control cannot be executed with the FC object when the following properties are “True”.

Tx_Enabled property
Ty_Enabled property

Usage Example

This example activates the force control function for the torque in the Z axis for the Force Trigger Object.

```
> FSet FT1.Tz_Enabled, True
```

Reference

Force Control Object FC#, Force Trigger Object FT#

Tx_Force, Ty_Force, Tz_Force Status

Application

Force Monitor Object FM#

Comments

This returns torque data for the specified axis.

Usage

FGet Object.**XX_Force**, *rVar*

Object Object name or string variable defining object name
The object is specified as either of FM (numerical value) or FM (label).

XX A character string defining the name of the property

rVar A real number variable defining the value of the property

Values

XX

Specified Axis	Description
Tx	Specifies X axis in the direction of rotation.
Ty	Specifies Y axis in the direction of rotation.
Tz	Specifies Z axis in the direction of rotation.

Detailed Explanation

This property is used to confirm the torque data for the specified axis of the force coordinate system specified by the CoordinateSystem.

Usage Example

This example establishes the force coordinate system 1 for the Force Monitor Object, and acquires the X axis torque data.

```
Function Test_Tx_Force
    Real rVar
    FSet FCS1.Position, 0, 0, 100
    FSet FCS1.Orientation, FG_TOOL
    FM1.ForceSensor, 1
    FSet FM1.CoordinateSystem, FCS1
    FGet FM1.Tx_Force, rVar
    Print rVar
Fend
```

Reference

Force Monitor Object FM#

Tx_Levels, Ty_Levels, Tz_Levels Property

Application

Force Trigger Object FT#

Comments

This sets or returns the values of the lower and upper thresholds for torque in the specified axis in the direction of rotation.

Immediate Execution

No

Usage

FGet *Object.XX*_**Levels**, *rArray()*

FSet *Object.XX*_**Levels**, *rValueL*, *rValueU*

Object	Object name, or string variable defining the object name The object is specified as either of FT (numerical value) or FT (label).
XX	A character string defining the name of the property
rArray()	The number of elements defining the values of the property is an array of 2 or more real number variables
rValueL	A real number or formula defining the new value of the property
rValueU	A real number or formula defining the new value of the property

Values

XX

Specified Axis	Description
Tx	Specifies X axis in the direction of rotation.
Ty	Specifies Y axis in the direction of rotation.
Tz	Specifies Z axis in the direction of rotation.

rArray()

Element number	Element number constant
0	FG_ LOWERLEVEL
1	FG_ UPPERLEVEL

rValueL (Unit: [N·mm])

	Values
Minimum	−100000 (default)
Maximum	100000

rValueU (Unit: [N·mm])

	Values
Minimum	−100000
Maximum	100000 (default)

Detailed Explanation

XX_Levels sets or returns the lower and upper torque threshold values for the specified axis in the direction of rotation.
rValueL is the lower threshold. rValueU is the upper threshold. Be sure that rValueL < rValueU.

This is used for error checking and task completion conditions.

Usage Example

This example generates an error and stops the robot when the Tx torque is below or above the lower or upper thresholds, respectively.

```
Function SettingLevels
   Set FT1.Enabled, False, False, False, True, False, False, False, False
   Set FT1.Tx_Polarity, FG_OUT
   Set FT1.Tx_Levels, -5000, 5000
   Trap 1, FT1 Call ForceError
Fend

Function ForceError
    AbortMotion All
Fend
```

Reference

Force Trigger Object FT#

Tx_LPF_Enabled, Ty_LPF_Enabled, Tz_LPF_Enabled Property

Application

Force Trigger Object FT#, Force Monitor Object FM#

Comments

This activates/inactivates or returns the status of the low-pass filter in the specified axis in the direction of rotation in the force coordinate system.

Immediate Execution

No

Usage

FGet Object.**XX_LPF_Enabled**, *bVar*

FSet Object.**XX_LPF_Enabled**, *bValue*

Object Object name, or string variable defining the object name
The object is specified as FT (numerical value), FT (label), FM (numerical value), or FM (label).

XX A character string defining the name of the property

bVar A Boolean variable defining the value of the property

bValue A Boolean value or formula defining the new value of the property

Values

XX

Specified Axis	Description
Tx	Specifies X axis in the direction of rotation.
Ty	Specifies Y axis in the direction of rotation.
Tz	Specifies Z axis in the direction of rotation.

bValue

Name of Constants	Values	Description
False	0	Sets the low-pass filter to inactive. (default)
True	–1	Sets the low-pass filter to active.

Detailed Explanation

This activates/inactivates or returns the status of the low-pass filter in the specified axis in the direction of rotation in the force coordinate system.

When the low-pass filter is active, signal noise can be reduced, but the following performance for quick signal changes deteriorates.

The low-pass filter is used with AvgForces Status, PeakForces Status, the Force Trigger Function, and Force Monitor, but is not used with Forces Status.

Usage Example

This example sets the Tx low-pass filter, and acquires the force data.

```
Function GetPeakForceTest
     Real myPeakForce
     FSet FCS1.Orientation, FG_TOOL
     FSet FM1.CoordinateSystem, FCS1
     FSet FM1.Tx_LPF_Enabled, True
     FSet FM1.Tx_LPF_TimeConstant, 0.02
     FSet FM1.PeakForceClear, True, True, True, True, True, True
     Wait 10
     FGet FM1.Tx_PeakForce, myPeakForce
     Print myPeakForce
Fend
```

Reference

Force Trigger Object FT#, Force Monitor Object FM#

Tx_LPF_TimeConstant, Ty_LPF_TimeConstant, z_LPF_TimeConstant Property

Application

Force Trigger Object FT#, Force Monitor Object FM#

Comments

This sets or returns the value of the low-pass filter setting applied to the specified axis in the direction of rotation in the force coordinate system.

Immediate Execution

No

Usage

FGet Object.**XX_LPF_TimeConstant**, *rVar*

FSet Object.**XX_LPF_TimeConstant**, *rValue*

Object	Object name, or string variable defining the object name The object is specified as FT (numerical value), FT (label), FM (numerical value), or FM (label).
XX	A character string defining the name of the property
rVar	A real number variable defining the value of the property
rValue	A real number or formula defining the new value of the property

Values

XX

Specified Axis	Description
Tx	Specifies X axis in the direction of rotation.
Ty	Specifies Y axis in the direction of rotation.
Tz	Specifies Z axis in the direction of rotation.

rValue (Unit: [sec])

	Values
Minimum	0.002
Maximum	5

Default: 0.01

Detailed Explanation

This sets the time constant for the low-pass filter or returns the status thereof for the specified axis in the direction of rotation for the force trigger function or force monitor function.

The low-pass filter time constant is the time it takes to arrive at an input value of $1\text{-}e^{-1}$ (approximately 63.2%) when giving step input.

The signal noise reduction can be enhanced when increasing the time constant, but the following performance for quick signal changes deteriorates.

The low-pass filter is used with AvgForces Status, PeakForces Status, the Force Trigger Function, and Force Monitor, but is not used with Forces Status.

Usage Example

This example sets the Tx low-pass filter, and acquires the force data.

```
Function GetPeakForceTest
     Real myPeakForce
     FSet FCS1.Orientation, FG_TOOL
     FSet FM1.CoordinateSystem, FCS1
     FSet FM1.Tx_LPF_Enabled, True
     FSet FM1.Tx_LPF_TimeConstant, 0.02
     FSet FM1.PeakForceClear, True, True, True, True, True, True
     Wait 10
     FGet FM1.Tx_PeakForce, myPeakForce
     Print myPeakForce
Fend
```

Reference

Force Trigger Object FT#, Force Monitor Object FM#

Tx_Mass, Ty_Mass, Tz_Mass Property

Application

Force Control Object FC#

Comments

This sets or returns the value of the virtual coefficient of inertia for force control in the specified axis in the direction of rotation in the force coordinate system.

Immediate Execution

No

Usage

FGet Object.**XX_Mass**, *rVar*

FSet Object.**XX_Mass**, *rValue*

Object Object name, or string variable defining the object name
The object is specified as either of FC (numerical value) or FC (label).

XX A character string defining the name of the property

rVar A real number variable defining the value of the property

rValue A real number or formula defining the value of the new property

Values

XX

Specified Axis	Description
Tx	Specifies X axis in the direction of rotation.
Ty	Specifies Y axis in the direction of rotation.
Tz	Specifies Z axis in the direction of rotation.

rValue (Unit: [mN·mm/(deg/sec^2)])

	Values
Minimum	1000
Maximum	10000000

Default: 30000

Detailed Explanation

This sets or returns the value of the virtual coefficient of inertia for force control in the specified axis in the direction of rotation in the established force coordinate system.

Refer to the following manual for details on coefficients.

EPSON RC+ 7.0 Option Force Guide 7.0

Usage Example

This example sets the Tx virtual coefficients of elasticity, viscosity, and inertia, and carries out a motion with force control active.

```
Function ForceControlTest
    FSet FCS1.Orientation, FG_TOOL
    FSet FC1.CoordinateSystem, FCS1
    FSet FC1.Enabled, False, False, False, True, False, False
    FSet FC1.Tx_Spring, 20000
    FSet FC1.Tx_Damper, 8000
    FSet FC1.Tx_Mass, 10000
    Move CurPos +TLW(10) FC1 ROT
Fend
```

Reference

Force Control Object FC#

Tx_PeakForce, Ty_PeakForce, Tz_PeakForce Status

Application

Force Monitor Object FM#

Comments

This returns the value of the peak torque in the specified axis in the direction of rotation.

Usage

FGet *Object.XX*_**PeakForce**, *rVar*

Object	Object name or string variable defining object name The object is specified as either of FM (numerical value) or FM (label).
XX	A character string defining the name of the property
rVar	A real number variable defining the value of the property

Values

XX

Specified Axis	Description
Tx	Specifies X axis in the direction of rotation.
Ty	Specifies Y axis in the direction of rotation.
Tz	Specifies Z axis in the direction of rotation.

Detailed Explanation

XX_PeakForce returns the peak torque for the specified axis in the direction of rotation.

Before executing XX_PeakForce, execute PeakForceClear.

Usage Example

This example measures the value of the peak torque in the Tx direction.

```
Function CheckPeakForce
  Double PF
  FSet FC1.Enabled, False, False, False, True, False, False
  FSet FC1.TargetForces, 0, 0, 0, 200, 0, 0
  FSet FS1.Reset
  FSet FM1.CoordinateSystem, FCS0
  FSet FM1.PeakForceClear, False, False, False, True, False, False, False,
False
  FCKeep FC1, 10
  FGet FM1.Tx_PeakForce, PF
  Print PF
Fend
```

Reference

Force Monitor Object FM#

Tx_Polarity, Ty_Polarity, Tz_Polarity Property

Application

Force Trigger Object FT#

Comments

This returns the status of or sets whether the force trigger is triggered when the value in the specified axis in the direction of rotation is within the thresholds or when the value in the specified axis in the direction of rotation is outside of the thresholds.

Immediate Execution

No

Usage

FGet Object.*XX*_**Polarity**, *iVar*

FSet Object.*XX*_**Polarity**, *iValue*

Object	Object name, or string variable defining the object name The object is specified as either of FT (numerical value) or FT (label).
XX	A character string defining the name of the property
iVar	An integer variable defining the value of the property
iValue	An integer value or formula defining the new value of the property

Values

XX

Specified Axis	Description
Tx	Specifies X axis in the direction of rotation.
Ty	Specifies Y axis in the direction of rotation.
Tz	Specifies Z axis in the direction of rotation.

iValue

Name of Constants	Values	Description
FG_OUT	0	Activates when the value is outside of the thresholds. (default)
FG_IN	1	Activates when the value is within the thresholds.

Detailed Explanation

XX_Polarity returns the status of or sets whether the force trigger is triggered when the value in the specified axis in the direction of rotation is within the thresholds or when the value in the specified axis in the direction of rotation is outside of the thresholds.

Usage Example

This example generates an error and stops the robot if the Tx torque is greater than the upper threshold or lower than the lower threshold.

```
Function SettingPolarity
   FSet FT1.Enabled, False, False, False, True, False, False, False,
False
   FSet FT1.Tx_Polarity, FG_OUT
   FSet FT1.Tx_Levels, -5000, 5000
   Trap 1, FT1 Call ForceError
Fend

Function ForceError
    AbortMotion All
Fend
```

Reference

Force Trigger Object FT#

Tx_Spring, Ty_Spring, Tz_Spring Property

Application

Force Control Object FC#

Comments

This sets or returns the value of the virtual coefficient of elasticity for force control in the specified axis in the direction of rotation in the force coordinate system.

Immediate Execution

No

Usage

FGet Object.**XX_Spring**, *rVar*

FSet Object.**XX_Spring**, *rValue*

Object Object name, or string variable defining the object name
The object is specified as either of FC (numerical value) or FC (label).

XX A character string defining the name of the property

rVar A real number variable defining the value of the property

rValue A real number or formula defining the new value of the property

Values

XX

Specified Axis	Description
Tx	Specifies X axis in the direction of rotation.
Ty	Specifies Y axis in the direction of rotation.
Tz	Specifies Z axis in the direction of rotation.

rValue (Unit: [N·mm/deg])

	Values
Minimum	0 (default)
Maximum	1000000

Detailed Explanation

This sets or returns the value of the virtual coefficient of elasticity for force control in the specified axis in the direction of rotation in the established force coordinate system.

Refer to the following manual for details on coefficients.

EPSON RC+7.0 Option Force Guide 7.0

Usage Example

This example sets the Tx virtual coefficients of elasticity, viscosity, and inertia, and carries out a motion with force control active.

```
Function ForceControlTest
    FSet FCS1.Orientation, FG_TOOL
    FSet FC1.CoordinateSystem, FCS1
    FSet FC1.Enabled, False, False, False, True, False, False
    FSet FC1.Tx_Spring, 20000
    FSet FC1.Tx_Damper, 8000
    FSet FC1.Tx_Mass, 10000
    Move CurPos +TLW(10) FC1 ROT
Fend
```

Reference

Force Control Object FC#

Tx_TargetForce, Ty_TargetForce, Tz_TargetForce Property

Application

Force Control Object FC#

Comments

This sets or returns the value of the target torque in the specified axis in the direction of rotation in the force coordinate system.

Immediate Execution

No

Usage

FGet *Object*.**XX_TargetForce**, r*Var*

FSet *Object*.**XX_TargetForce**, r*Value*

Object	Object name, or string variable defining the object name The object needs to be specified as either of FC (numerical value) or FC (label).
XX	A character string defining the name of the property
rVar	A real number variable defining the value of the property
rValue	A real number or formula defining the value of the new property

Values

XX

Specified Axis	Description
Tx	Specifies X axis in the direction of rotation.
Ty	Specifies Y axis in the direction of rotation.
Tz	Specifies Z axis in the direction of rotation.

rValue (Unit: [N·mm])

	Values
Minimum	The rated negative detection capability of the force sensor
Maximum	The rated positive detection capability of the force sensor

Default: 0

Detailed Explanation

This sets or returns the value of the target torque in the specified axis in the direction of rotation in the force coordinate system.

When the force control function is executed with the target torque being set to “0”, the robot operates while following the external force because it moves so that the force becomes “0”.

When using the force control function having set the target torque, there are times that the target force is not achieved even after sufficient time. In such instances, activate the TargetForcePriorityMode when wanting to accurately match the target force. However, when the TargetForcePriorityMode is activated, operation of the robot will not be in accordance with the established values for the virtual coefficients of elasticity, viscosity, and inertia, and the motion may be slowed at times.

Usage Example

This example sets the Tx virtual coefficients of elasticity, viscosity, and inertia and the target torque, and carries out a motion with force control active.

```
FSet FCS1.Orientation, FG_TOOL
FSet FC1.CoordinateSystem, FCS1
FSet FC1.Enabled, False, False, False, True, False, False
FSet FC1.Tx_Spring, 20000
FSet FC1.Tx_Damper, 8000
FSet FC1.Tx_Mass, 10000
FSet FC1.Tx_TargetForce, 0.1
FCKeep FC1, 5
```

Reference

Force Control Object FC#

UpperLevels Property

Application

Force Trigger Object FT#

Comments

This sets or returns the value of the upper threshold for force and torque on each axis at the same time.

Immediate Execution

No

Usage

FGet *Object*.**UpperLevels**, rArray*()*

FSet *Object*.**UpperLevels**, *rValueFx*, *rValueFy*, *rValueFz*, *rValueTx*, *rValueTy*, *rValueTz [,rValueFmag ,rValueTmag]*

Object	Object name, or string variable defining the object name The object is specified as either of FT (numerical value) or FT (label).
rArray()	The maximum number of elements defining the value of the property is an array of 8 or more real number variable
rValueFx	A real number or formula defining the new value of the property.
rValueFy	A real number or formula defining the new value of the property.
rValueFz	A real number or formula defining the new value of the property.
rValueTx	A real number or formula defining the new value of the property.
rValueTy	A real number or formula defining the new value of the property.
rValueTz	A real number or formula defining the new value of the property.
rValueFmag	A real number or formula defining the new value of the property.
rValueTmag	A real number or formula defining the new value of the property.

Values

rArray()

Element number	Element number constant	Description
0	FG_FX	Acquires the upper threshold for Fx force.
1	FG_FY	Acquires the upper threshold for Fy force.
2	FG_FZ	Acquires the upper threshold for Fz force.
3	FG_TX	Acquires the upper threshold for Tx torque.
4	FG_TY	Acquires the upper threshold for Ty torque.
5	FG_TZ	Acquires the upper threshold for Tz torque.
6	FG_FMAG	Acquires the upper threshold for Fmag resultant force.
7	FG_TMAG	Acquires the upper threshold for Tmag resultant torque.

Note: When the number of elements is an array of 6 or 7, the element numbers acquired are 0 to 5.

rValueFx, rValueFy, rValueFz (Unit: [N])

	Values
Minimum	−1000
Maximum	1000 (default)

rValueTx, rValueTy, rValueTz (Unit: [N·mm])

	Values
Minimum	−100000
Maximum	100000 (default)

rValueFmag (Unit: [N])

	Values
Minimum	0
Maximum	1000 (default)

rValueTmag (Unit: [N·mm])

	Values
Minimum	0
Maximum	100000 (default)

Detailed Explanation

UpperLevels sets or returns the value of the upper threshold for force and torque on each axis at the same time.

Be sure that LowerLevels < UpperLevels.

Since all force upper threshold values for each axis are set at one time, it can be done with fewer lines than setting them one axis at a time.

This is used for error checking and task completion conditions.

Usage Example

This example generates an error and stops the robot when the force is greater than the upper threshold.

```
Function SettingLevels
     FSet FT1.Enabled, True, True, True, True, True, True, True, True
     FSet FT1.Polarities, FG_OUT, FG_OUT, FG_OUT, FG_OUT, FG_OUT,
FG_OUT, FG_OUT, FG_OUT
     FSet FT1.UpperLevels, 50, 50, 50, 3000, 3000, 3000, 50, 3000
    Trap 1, FT1 Call ForceError
Fend

Function ForceError
    AbortMotion All
Fend
```

Reference

Force Trigger Object FT#