Stopping and Braking Attributes

These are the active stopping and braking related attributes associated with a Motion Control Axis.

Stopping Action

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Required - D	Set	USINT	FD 1 for C 0 for F	-	-	Enumeration: 0 = Disable and Coast 1 = Current Decel and Disable 2 = Ramped Decel and Disable 3 = Current Decel and Hold 4 = Ramped Decel and Hold 5-127 = Reserved 130-255 = (vendor specific) 128 = DC Injection Brake 129 = AC Injection Brake

 # Indicates the attribute cannot be set while the tracking command (Tracking Command bit in CIP Axis Status is true).

When disabling or aborting an axis, through a Disable Request or an Abort Request this value determines the stopping method to apply to the motor. Each supported Stopping Action initiates one of three Stopping Sequences (IEC60204-1 Category Stops 0, 1, and 2).

- In the case of a Disable Request, the stopping method is applied while in the Stopping state and the final state after the stopping method is completed is the Stopped state.
- In the case of an Abort Request, the stopping method is applied while in the Aborting state and the final state after the stopping method completes is the Major Faulted state.

In either final state the device's inverter power structure will either be Disabled (Disable selection) and free of torque or actively held (Hold selection) in a static condition. This attribute has no impact or relationship to the planner generated acceleration and deceleration profiles. This attribute does not, in any way, determine the stopping actions applied in response to fault conditions.

Connection Loss Stopping Action

Usage	Access	Data Type	Default	Min	Max	Semantics of Values

Optional - D	Set	USINT	FD 1 for C 0 for F	-	-	Enumeration: 0 = Disable and Coast 1 = Current Decel and Disable 2 = Ramped Decel and Disable 3 = Current Decel and Hold 4 = Ramped Decel and Hold 5-127 = Reserved 128-255 = Vendor Specific

 # Indicates the attribute cannot be set while the tracking command (Tracking Command bit in CIP Axis Status is true).

When a CIP Motion connection loss is detected, this value determines the stopping method to apply to the motor. Each supported Stopping Action initiates the associated Stopping Sequence (IEC60204-1 Category Stops 0, 1, and 2). If the connection is closed intentionally using a Forward Close service, the selected stopping method is applied while in the Stopping state and the final state after the stopping method completes is the Initializing state. If the connection is unintentionally lost and the resulting Node Fault generated (Node Fault Codes 1 or 6), the selected stopping method is applied while in the Aborting state and the final state after the stopping method completes is the Major Faulted state. In either final state the device's inverter power structure will either be Disabled (Disable selection) and free of torque or actively held (Hold selection) in a static condition.

Stopping Action Enumeration Definitions

Enum.	Usage	Name	Description
0	R/D	Disable and Coast	Disable and Coast immediately disables the device power structure and active control loops, which causes the motor to coast unless some form of external braking is applied. This is equivalent to an IEC-60204-1 Category 0 Stop.

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Converter Current Control Configuration Attributes
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Converter Current Reference Configuration Attributes
Converter Current Reference Signal Attributes
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Exception User Limit Configuration Attributes
Exception, Fault and Alarm Attributes
Exceptions
Fault and Alarm Behavior
Feedback Interface Types
Feedback Configuration Attributes
Frequency Control Configuration Attributes
Frequency Control Signal Attribute
General Feedback Info Attributes
General Feedback Signal Attributes
General Linear Motor Attributes
General Motor Attributes
General Permanent Magnet Motor Attributes
General Rotary Motor

1	R/C O/F	Current Decel and Disable	Current Decel and Disable leaves the power structure and any active control loops enabled while stopping. If configured for position control mode, the drive forces the position reference to hold its current value until the axis reaches zero speed. Once at zero speed the position reference is immediately set equal to the actual position to hold the axis at standstill. If in velocity control mode, the drive forces the velocity reference to zero. In either case, forcing the position or velocity reference signals to a fixed value results in a rapid increase in control loop error of the moving axis that saturates the output current of the drive to the configured Stopping Torque that brings the motor to a stop. In torque control mode, the drive directly applies the configured Stopping Torque to the torque command signal to decelerate the motor. When the velocity feedback value reaches zero speed, the torque command is set to zero. Once stopped, or the configured Stopping Time or factory time limit expires, the drive disables the power structure and control loops. This stop mode complies with the IEC-60204-1 Category 1 Stop. In frequency control mode the operative current limit, rather than the Stopping Torque attribute, is used to regulate the stopping current.
2	O/FV	Ramped Decel and Disable	Ramped Decel and Disable also leaves the power structure and any active control loops enabled while stopping but uses the Ramp Generator associated with the Velocity Fine Command Generator block to decelerate the motor to a stop. When initiating a Ramped Decel and Disable Stop, the Ramp Generator is immediately activated and the drive no longer follows command from the controller. The Ramp Generator input is initialized to zero and the output is initialized to the current speed of the motor, thus causing the Ramp Generator output to ramp the motor from its current speed down to zero according to the ramp control parameters. Once stopped, or the configured Stopping Time or factory timeout limit expires, the device disables the power structure and control loops. This stop mode also complies with the IEC-60204-1 Category 1 Stop.
3	O/PV	Current Decel and Hold	Current Decel and Hold behaves like Current Decel and Disable, but leaves the power structure active with holding torque to maintain the stopped condition. The method for generating holding torque is left to the drive vendor's discretion. This stop mode complies with the IEC-60204-1 Category 2 Stop. The Current Decel and Hold stopping action is not allowed if a Start Inhibit condition is present. If a Start Inhibit condition is present, a Current Decel and Disable will be initiated instead.

4	O/V	Ramped Decel and Hold	Ramped Decel and Hold behaves like Ramped Decel and Disable, but leaves the power structure with holding torque to maintain the stopped condition. This stop modes also complies with the IEC-60204-1 Category 2 Stop. The Ramped Decel and Hold stopping action is not allowed if a Start Inhibit condition is present. If a Start Inhibit condition is present, a Ramped Decel and Disable will be initiated instead.
5-127		Reserved	
128-255		Vendor Specific	
128	O/D	DC Injection Brake	DC Injection Brake immediately applies the configured DC Injection Brake Current to the motor to create a static flux field to bring an induction motor to a stop before disabling the power structure.
129	O/D	AC Injection Brake	AC Injection Brake decreases the device output frequency from its present value to zero at the rate determined by the configured Deceleration Limit. Stopping action is accomplished by lowering the output frequency below the motor rotor speed where regeneration does not occur and instead mechanical energy is dissipated in the motor as heat.

Stopping Torque

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Required - C	Set	REAL	100 FD	0	10^3	% Motor Rated

When disabling or aborting an axis, this value determines the maximum amount of torque producing current available to stop the motor when the Stopping Action is set to Current Decel. If this attribute is not supported, the drive device will use the configured Positive and Negative Peak Current Limits.

Stopping Time Limit

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Optional - D	Set	REAL	1	0	10^3	Seconds

When disabling or aborting an axis, this parameter determines the maximum amount of time the drive allows to reach zero speed as part of the Category 1 or Category 2 Stop sequence. Action taken by the drive once the time limit is reached depends on the Stop Category. For a Category 1 Stop, the drive continues to apply Stopping Torque while engaging the brake. For a Category 2 Stop the drive continues to apply Stopping Torque but does not engage the brake. If Stopping Time Limit is not supported a factory set timeout may be applied.

Coasting Time Limit

Usage	Access	Data Type	Default	Min	Max	Semantics of Values

Optional - D	Set	REAL	0 FD	0	10^3	Seconds

When disabling or aborting an axis, this parameter determines the maximum amount of time the drive allows to reach zero speed as part of the Category 0 "Disable and Coast" Stop sequence. Action taken by the drive if the time limit is reached is to engage the brake and advance to the Stopped state. If this attribute is not supported, the Coasting Time Limit applies the Stopping Time Limit value. If Stopping Time Limit is not supported a factory set timeout may be applied.

Resistive Brake Contact Delay

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Optional - D (PM Motor)	Set	REAL	0	0	10^3	Seconds

When an external resistive brake is used, the Resistive Brake Contact Delay can be set to delay the enabling of the device power structure until after the resistive brake has had time to connect the motor to the drive device. When an external resistive brake is used, an external contactor switches the UVW motor leads from the inverter power structure to an energy dissipating resistor to stop the motor. Note that this switching does not occur instantaneously and so enabling the power structure too early can cause electrical arcing across the contactor. To prevent this condition, the Resistive Brake Contact Delay can be set to the maximum time that it takes to fully close the contactor across the UVW motor lines so when the axis is enabled, the inverter power structure is not enabled until after the Resistive Brake Contact Delay Time has expired. Resistive Brake operation is only applicable to PM Motor types.

The following sequence further defines how the Resistive Brake Contact Delay factors into the overall Enable Sequence that may also include the operation of a Mechanical Brake.

Enable Sequence:

1. Switch to Starting state.
2. Activate Resistive Brake contactor to connect motor to inverter power structure.
3. Wait for "Resistive Brake Contact Delay" while Resistive Brake contacts close.
4. Enable inverter power structure.
5. Activate Mechanical Brake output to release brake.
6. Wait for "Mechanical Brake Release Delay" while brake releases.
7. Transition to Running state.

Mechanical Brake Control

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Optional - D	Set	USINT	0	-	-	Enumeration 0 = Automatic 1 = Brake Release 2-225 = Reserved

The Mechanical Brake Control attribute governs the operation of the drive's Mechanical Brake Output that controls the mechanical brake mechanism. When set to Automatic, the Mechanical Brake is under the control of the axis state machine. The sequencing for the

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brake is described in detail by the Mechanical Brake Engage Delay and Mechanical Brake Release Delay attributes. When set to Brake Release, the brake is unconditionally released, and no longer under the control of the axis state machine.

Mechanical Brake Release Delay

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Optional - D	Set	REAL	0 FD	0	10^3	Seconds

When enabling the axis, the Mechanical Brake Release Delay value determines the amount of time the device will delay transition from the Starting state to the Running or Testing states. This delay prevents any commanded motion of the motion axis until the external mechanical brake has had enough time to disengage. If supported, a Torque Proving operation is included in this sequence prior to releasing the brake.

Enable Sequence:

1. Switch to Starting state.
2. Activate Resistive Brake contactor to connect motor to inverter power structure.
3. Wait for "Resistive Brake Contact Delay" while Resistive Brake contacts close.
4. Enable inverter power structure.
5. Perform (optional) Torque Proving operation to verify motor control of load.
6. Activate Mechanical Brake output to release brake.
7. Wait for "Mechanical Brake Release Delay" while brake releases.
8. Transition to Running (or Testing) state.

Mechanical Brake Engage Delay

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Optional - D	Set	REAL	0 FD	0	10^3	Seconds

When disabling the motion axis using a Category 1 Stopping Action, the Mechanical Brake Engage Delay value determines the amount of time the device power structure will remain enabled after the axis has decelerated to standstill. This attribute allows time for an external mechanical brake to engage. The configured Stopping Action determines the type of stopping sequence applied. If supported, a Brake Proving operation is included in the Category 1 stopping sequence prior to disabling the power structure.

Zero Speed

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Optional - D	Set	REAL	1 FD	0	∞	% Motor Rated

This attribute sets the speed threshold associated with the zero speed criteria of the stop sequence. Zero Speed is specified as a percent of motor rated speed. When Zero Speed Time attribute is supported, this attribute sets the speed threshold where the zero speed timer starts. When the axis speed has been below the Zero Speed threshold for Zero Speed Time the axis has satisfied the zero speed criteria. In all but Category 2 stops, this results in action to engage the mechanical brake. If this attribute is not supported, the zero speed threshold is left to the vendor's discretion and typically set to 1% of motor

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rated speed. Axis speed in the above description is based on the Velocity Feedback signal, or in the case of a Frequency Control drive, axis speed is based on Velocity Reference signal.

When supporting a Load Observer, the zero speed criteria is not based on the Velocity Estimate since that signal can differ considerably from the actual speed of the motor. When the Load Observer is configured to apply the Velocity Estimate to the velocity loop summing junction as Velocity Feedback, the zero speed criteria must be based on the velocity feedback signal input to the Load Observer.

Zero Speed Time

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Optional - D	Set	REAL	0	0	10^3	Sec

This attribute sets the amount of time that the axis speed must be below the zero speed threshold, set by the Zero Speed attribute or established by the drive vendor, before satisfying the zero speed criteria. In all but Category 2 stops, when this attribute is set it results in action to engage the mechanical brake. If this attribute is not supported, the amount of time needed to satisfy the zero speed criteria is left to the vendor's discretion and typically is immediate (0). Axis speed in the above description is based on the Velocity Feedback signal, or in the case of a Frequency Control drive, axis speed is based on Velocity Reference signal.

When supporting a Load Observer, the zero speed criteria is not based on the Velocity Estimate since that signal can differ considerably from the actual speed of the motor. When the Load Observer is configured to apply the Velocity Estimate to the velocity loop summing junction as Velocity Feedback, the zero speed criteria must be based on the velocity feedback signal input to the Load Observer.

Vertical Load Control

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Optional - FPV	Set	USINT	0	-	-	Enumeration: 0 = Disabled 1 = Enabled 2 - 255 = Reserved

This enumerated value allows the drive to tailor motor control behavior for vertical load applications. When the Enabled enumeration is selected, the drive attempts, whenever possible, to avoid applying Category 0 stop actions in response to Major Fault conditions. The drive may tailor other aspects of its behavior to best handle vertical loads.

Proving Configuration

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Optional - D	Set	USINT	0 FD	-	-	Enumeration: 0 = Disabled 1 = Enabled 2 - 255 = Reserved

This attribute enables the operation of the drive's Torque Proving and Brake Proving functions that work in conjunction with mechanical brake control. When Proving is

functions that work in conjunction with mechanical brake control. When Proving is enabled, the mechanical brake must be set as soon as the drive is disabled. When the

brake is under the control of the axis state machine this is automatic. But when controlled externally, failure to set the brake when the drive is disabled can cause a free fall condition on a vertical application.

When enabled, the drive performs a Torque Prove test of the motor current while in the Starting state to "prove" that current is properly flowing through each of the motor phases before releasing the brake. Should the Torque Prove test fail, a Motor Phase Loss exception is generated.

While Torque Proving functionality is applicable to drive Control Modes that are not capable of generating reliable holding torque based on a feedback device, such as Frequency Control and Sensorless Velocity Control, Torque Proving should not be used in these modes for applications where holding torque is critical to safe operation, such as in a typical lift or crane application.

If the optional Brake Test Torque attribute is supported, the Torque Prove test also includes a proactive Brake Test to ensure the mechanical brake is functioning properly. Should the Brake Test detect brake slip, a Brake Slip exception is generated.

When Proving is enabled, the drive also performs a Brake Prove test while in the Stopping or Aborting states to "prove" proper mechanical brake function before the drive power structure is disabled. Should the Brake Prove test detect brake slip a Brake Slip exception is generated.

Unless another vendor specific method is used to address a Brake Slip condition in the Stopping or Aborting state, the appropriate Fault Action for the Brake Slip exception is Torque Limited Stop and Hold. This Fault Action applies holding torque to arrest the brake slip and transitions the axis to the Major Faulted state.

In general, Brake Proving functionality is only applicable to drive Control Modes that are capable of generating holding torque based on a feedback device. Brake Proving is therefore not applicable to Frequency Control or Sensorless Velocity Control modes.

When Proving is enabled, and the Auto-Sag feature is supported, upon detection of a brake slip condition, the drive has the capability of safely lowering the load to the ground in a controlled series of increments. The Auto Sag Configuration attribute is used to enable this feature. In addition to Brake Slip initiating a Brake Slip exception, the drive also generates a Brake Malfunction start inhibit when the Auto Sag feature is enabled.

When Proving, Auto Sag, and Auto Sag Start are all enabled, the drive also monitors for brake slip in the Stopped or Faulted states. If brake slip is detected, the drive power structure is automatically started to arrest the slip allowing the Auto Sag function to safely lower the load to the ground. Upon detection of brake slip, a Brake Slip exception is generated along with a Brake Malfunction start inhibit.

The sequencing of the torque and brake "prove" tests are described in detail by the Mechanical Brake Engage Delay and Mechanical Brake Release Delay attributes.

The Proving feature includes a number of optional Sub-Features, many of which depend on support of other Proving feature attributes. The following table defines these attribute dependencies.

Proving Sub-Feature	**Controlling Attributes**	**Attribute Prerequisites**
Torque Prove	Torque Prove Current	Proving Configuration
Brake Test	Brake Test Torque Brake Slip Tolerance	Proving Configuration
Brake Prove	Brake Prove Ramp Time Brake Slip Tolerance	Proving Configuration

Auto Sag	Auto Sag Configuration Auto Sag Slip Increment	Proving Configuration Brake Prove Ramp Time Brake Slip Tolerance
Auto Sag Start	Auto Sag Start	Proving Configuration Brake Prove Ramp Time Brake Slip Tolerance Auto Sag Configuration Auto Sag Slip Tolerance

Proving tests are performed when enabling or disabling the drive axis. During these state transitions a series of operations are performed by the drive to ensure the proper function of the motor (Torque Proving) and the brake (Brake Proving).

Torque Prove Current

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Optional - D	Set	REAL	0 FD	0	10^3	% Motor Rated

This attribute sets the percent of motor rated torque applied to the motor by the Torque Prove test as part of the Torque Proving function executed in the Starting state. The Torque Prove test applies current to the motor to "prove" that current is properly flowing through each of the motor phases before releasing the brake.

Brake Test Torque

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Optional - DE	Set	REAL	0 FD	0	10^3	% Motor Rated

This attribute sets the percent of motor rated torque applied to the motor by the Brake Test as part of the Torque Proving function executed in the Starting state. This Brake Test proactively tests the ability of the mechanical brake to hold the maximum anticipated load before releasing the brake and allowing operation. Should the Brake Test detect brake slip, a Brake Slip exception is generated.

If the Brake Test Torque attribute value is 0 the Brake Test is not performed in the Starting state.

Brake Prove Ramp Time

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Optional - DE	Set	REAL	0 FD	0	10^3	Seconds

This attribute determines the amount of time the drive will take to ramp the applied torque of the motor down to zero during the Brake Proving test in the Stopping or Aborting state. The Brake Prove Ramp Time determines the ramp down rate of the

applied torque output by dividing the Torque Limit by the Brake Prove Ramp Time. The

Torque Limit in this case is the maximum of the configured Torque Limit Positive and Torque Limit Negative values. The Brake Prove test is performed to check for brake slip before the power structure is disabled.

Brake Slip Tolerance

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Optional - DE	Set	REAL	0 FD	0	∞	Position Units

This attribute determines the amount of brake slip allowed after the brake is engaged. If this tolerance is exceeded while the brake is engaged, a Brake Slip exception is generated. Brake slip can therefore be monitored in any axis state where the brake is engaged.

DC Injection Brake Current

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Optional - D	Set	REAL	0	0	10^3	% Motor Rated

The DC Injection Brake Current attribute defines the brake current level injected into an induction motor stator when DC Injection Brake is selected as the Stopping Action. This attribute is specified as a percent of motor rated speed.

DC Injection Brake Time

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Optional - D	Set	REAL	0	0	10^3	Seconds

The DC Injection Brake Time attribute defines the amount of time that the DC brake current is injected into an induction motor stator when DC Injection Brake is selected as the Stopping Action. This attribute is specified in seconds.

Flux Braking Enable

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Optional - D (Induction Motor)	Set	USINT	0	0	1	0 = Flux Braking Disabled 1 = Flux Braking Enabled

The Flux Braking Enable attribute value determines if the drive device is to apply additional flux current to the induction motor in an effort to increase motor losses and reduce the deceleration time while in the Stopping state. This feature is useful when there is no Shunt Regulator or Regenerative Brake available.

Auto Sag Configuration

Usage	Access	Data Type	Default	Min	Max	Semantics of Values

Optional - DE	Set/SSV	USINT	0	-	-	Enumeration: 0 = Disabled 1 = Enabled 2-255 = (reserved)

This attribute is used to enable the optional Auto Sag feature that, in the event of detected a brake slip condition, safely lowers the load to the floor in a series of controlled Auto Sag Slip Increments. When a brake slip condition is detected and Auto Sag is enabled, the drive not only sets the standard Brake Slip exception, but the drive also sets the Brake Malfunction start inhibit. This prevents the drive from restarting after the load has been safely lowered to the floor.

Auto Sag Slip Increment

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Optional - DE	Set	REAL	0	0		Position Units

This attribute sets the incremental amount of brake slip allowed by the drive's optional Auto Sag function before restoring holding torque. When brake slip occurs, the drive allows this amount of displacement and then automatically enables the power structure and applies holding torque to arrest the slip. The drive then ramps the motor torque to zero based on the Brake Prove Ramp Time while checking for slip. Should brake slip continue, the cycle repeats. In crane and lift applications, this repeating "Auto Sag" cycle is designed to lower the load in a controlled series of Auto Sag Slip Increments until the load reaches the ground.

Auto Sag Slip Time Limit

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Optional - DE	Set	REAL	0.25	0		Seconds

This attribute sets the time limit over which the drive checks for brake slip as performed by the Auto Sag function before restoring holding torque. When brake slip occurs, the drive allows this amount of time before automatically enabling the power structure and applying holding torque. The drive then ramps the motor torque to zero based on the Brake Prove Ramp Time while checking for slip. Generally, in a brake slip situation, the Auto Sag Slip Time Limit expires when the load reaches the ground after one or more Auto Sag Slip Increment cycles. With no further slip occurring while the motor torque is ramping to zero, the Auto Sag feature transitions the axis to the Major Faulted state and the drive power structure is disabled.

The optional Auto Sag Slip Time Limit attribute is not required by the Auto Sag feature. If not supported, a vendor specific value for the Auto Sag Slip Time is applied, typically 0.25 seconds.

Auto Sag Start

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Optional - DE	Set/SSV	USINT	0	-	-	Enumeration: 0 = Disabled 1 = Enabled 2-255 = (reserved)

When the Auto Sag Configuration attribute is set to Enabled, this attribute is used to enable the Auto Sag function in the Stopped or Faulted state. When Auto Sag Start is enabled, the drive monitors the load for possible brake slip and should the amount of brake slip exceed the Brake Slip Tolerance a Brake Slip exception is generated, along with a Brake Malfunction start inhibit. When this occurs, the drive power structure is enabled (Started) without holding torque and the axis transitions to the Aborting State. The drive continues to monitor brake slip and when the amount of slip exceeds the Auto Sag Slip Increment holding torque is applied to the motor to arrest the brake slip. The drive then ramps the motor torque to zero based on the Brake Prove Ramp Time while again checking for slip. Should brake slip continue and exceed the Auto Sag Slip Increment, holding torque is applied and the cycle repeats. In crane and lift applications, this repeating "Auto Sag" cycle is designed to lower the load in a controlled series of Auto Sag Slip Increments until the load reaches the ground.

See also

Stopping Sequences

Proving Operation Sequences

State Behavior

Motor Attributes

CIP Axis Attributes

How are we doing?