Instruction Set > CIP Axis Attributes > Motion Scaling Attributes

Search

Motion Scaling Attributes

These are the basic motion scaling configuration attributes associated with a Motion Control Axis. These attributes are involved in conversion between position, speed, and acceleration expressed in Motion Counts and Motion Units, and the user-defined Position Unit of the axis. The motion scaling function is also involved in conversion of Motion Counts to/from Feedback Counts, and Motion Units to/from Feedback Units.

Motion Scaling Configuration

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Required - All	Set/GSV	USINT	0	-	-	Enumeration 0 = Control Scaling (R) 1 = Drive Scaling (O) 2-255 = Reserved

The Motion Scaling Configuration attribute determines whether the scaling function is performed by the controller or the drive. The Control Scaling selection configures the control system to perform the scaling calculations in the controller. In this mode, the controller interacts with the drive in terms of Feedback Counts or Motor Units, hence no scaling operations are required by the drive. Also, in Control Scaling mode the controller is responsible for Position Unwind (Cyclic Unwind for device axis objects) operations associated with Cyclic Travel Mode (Cyclic Unwind Control for device axis objects).

The Drive Scaling selection configures the control system to perform the scaling calculations in the drive device. In this mode, the controller interacts with the drive in terms of Motion Counts or Motion Units and the drive is responsible for conversion to equivalent Feedback Counts and Motor Units. Also, in Drive Scaling mode the drive is responsible for Position Unwind (Cyclic Unwind) operations associated with Cyclic Travel Mode (Cyclic Unwind Control).

Scaling Source

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Required - All	Set/ SSV#	USINT	0	-	-	Enumeration: 0 = From Calculator 1 = Direct Scaling Factor Entry 2-255 = reserved

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

Enumerated attribute used to determine whether the scaling factors are going to be entered directly from the user or calculated based on Position Scaling, Position Unwind, and Travel Range values. When entered directly, the scaling factors, for example, Conversion Constant, Position Unwind, and Motion Resolution are expressed in units of "counts". When using the scaling calculator, the scaling factors are calculated based on values entered by the user in the preferred units of the application without requiring any knowledge of "counts".

Important:	Configuration of Scaling page parameters is required for any attributes expressed in position, velocity, or acceleration units to return meaningful values.

Scaling Calculations are performed by Logix Designer application whenever the Scaling attribute values change. Scaling attributes are defined as Position Scaling Numerator, Position Scaling Denominator, Position Unwind Numerator, Position Unwind Denominator, Travel Mode, and Travel Range. The purpose of the Scaling Calculation is to generate the key Scaling Factors used to convert between the user defined Position Units and the quantized Motion Count units used by the control system. The set of Scaling Factor attributes consist of Motion Resolution, Conversion Constant, and Position Unwind.

The specific Scaling Calculations performed by the Logix Designer application depend on the Travel Mode setting as follows:

Cyclical Travel:

- Max Resolution = Int((2^31-1) * (Pos Scaling Num/Pos Scaling Denom) / (Unwind Num/Unwind Denom))
- Base Resolution = Minimum (Default Motion Resolution, Max Resolution)
- Motion Resolution = (Pos Scaling Num*Unwind Denom) * (10^(Int (Log10(Base Resolution/(Pos Scaling Num*Unwind Denom)))))
- Conversion Constant = Motion Resolution * (Pos Scaling Denom/Pos Scaling Num)
- Unwind = Conversion Constant * (Unwind Num/Unwind Denom)

Limited Travel:

- Max Resolution = Int((2^31-1) * (Pos Scaling Num/Pos Scaling Denom) / Travel Range)
- Base Resolution = Minimum (Default Motion Resolution, Max Resolution)
- Motion Resolution = Pos Scaling Num * (10^(Int (Log10(Base Resolution/Pos Scaling Num))))
- Conversion Constant = Motion Resolution * (Pos Scaling Denom/Pos Scaling Num)

Unlimited Travel:

- Base Resolution = Default Motion Resolution
- Motion Resolution = Pos Scaling Num * (10^(Int (Log10(Base Resolution/Pos Scaling Num))))
- Conversion Constant = Motion Resolution * (Pos Scaling Denom/Pos Scaling Num)

When Scaling Calculations are performed, Logix Designer application sets the Scaling Source to "from calculator". If any of the Scaling Factor attributes is changed directly by the user either through Logix Designer or through programmatic access, Scaling Source is set to "direct entry". The "direct entry" setting indicates that the Scaling Factors are no longer consistent with the current Scaling attribute values.

Travel Mode

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Required - All	Set/ SSV#	USINT	0	-	-	Enumeration: 0 = Unlimited 1 = Limited (E) 2 = Cyclic (E) 3-255 = reserved

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

Enumerated attribute used to determine the travel constraints of the axis. Unlimited travel is for axes that run continuously without limit but are not cyclic. Limited travel is for axes that have imposed limits to their travel, usually due to mechanical limitations. Cyclic travel is for axes whose position repeats as part of a product cycle. While the axis may run continuously, the position value is bound between 0 and the Position Unwind value. If the Feedback Configuration = No Feedback, such as with Sensorless/Encoderless operation, then the only valid Travel Mode setting is "Unlimited".

Position Scaling Numerator

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Required - All	Set/ GSV	REAL	1	0+	∞	Position Units

A floating point value used by the scaling calculator to determine the number of Position Units per Position Scaling Denominator units (Motion Units).

Position Scaling Denominator

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Required - All	Set/ GSV	REAL	1	0+	∞	Motion Unit

A floating point value used by the scaling calculator to determine the number of Motion Units per Position Scaling Numerator units (Position Units).

Position Unwind Numerator

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Required - E	Set/ GSV	REAL	1	0+	∞	Position Units

A floating point value used by the scaling calculator to determine the number of Position Units per Position Unwind Denominator units (Unwind Cycles). This value is only used by the calculator if cyclic Travel Mode is selected.

Position Unwind Denominator

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Required - E	Set/ GSV	REAL	1	0+	∞	Unwind Cycles

A floating point value used by the scaling calculator to determine the number of Unwind Cycles per Position Unwind Numerator units (Position Units). This value is only used by the calculator if cyclic Travel Mode is selected.

Travel Range

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Required - E	Set/ GSV	REAL	1	0+	∞	Position Units

A floating point value used by the scaling calculator to determine the maximum travel

A floating point value used by the scaling calculator to determine the maximum travel range in Position Units for a limited Travel Mode position scaling calculation.

Motion Unit

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Required - All	Set/ GSV	USINT	0	-	-	Enumeration 0 = Motor Rev 1 = Load Rev 2 = Feedback Rev 3 = Motor mm 4 = Load mm 5 = Feedback mm 6 = Motor inch 7 = Load inch 8 = Feedback inch 9 = Motor Rev/s 10 = Load Rev/s 11 = Motor m/s 12 = Load m/s 13 = Motor inch/s 14 = Load inch/s 15-255 = Reserved

The Motion Unit attribute determines the unit of measure used to express the Motion Resolution used by motion planner functions. A Motion Unit is the standard engineering unit of measure for motion displacement. Motion Units may be configured as Revs, Inches, or Millimeters depending on the specific application.

Motion Resolution

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Required - All	Set/ SSV#	DINT	Default Motion Resolution	1	2^{31}-1	Motion Counts / Motion Unit

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

The Motion Resolution attribute is an integer value that determines the number of Motion Counts per Motion Unit used by the scaling function to convert between Motion Counts and Feedback Counts. This attribute determines how many Motion Counts there are in a Motion Unit. A Motion Count is the fundamental unit of displacement used by the Motion Planner and a Motion Unit is the standard engineering unit of measure for motion displacement. Motion Units may be configured as Revs, Inches, or Millimeters depending on the specific application.

All command position, velocity, and acceleration data is scaled from the user's preferred Position Units to Motion Units for the Motion Planner based on the Motion Resolution and Conversion Constant. The ratio of the Conversion Constant to Motion Resolution determines the number of Position Units in a Motion Unit as described using the following formula.

- Conversion Constant / Motion Resolution = Motion Units (revs, inches, or millimeters) / Position Unit

Conversely, all actual position, velocity, and acceleration data from the Motion Planner is scaled from Motion Units to the user's preferred Position Units based on the Motion Resolution and Conversion Constant. The ratio of Motion Resolution and the Conversion Constant determines the number of Position Units in a Motion Unit as described using the following formula:

- Motion Resolution / Conversion Constant = Position Units / Motion Unit (rev, inch, or millimeter)

In general, the Motion Resolution value may be may be configured in Motion Counts per Motion Unit independent of the resolution of the feedback device(s) used. The drive's scaling function takes care of scaling between Feedback Counts and Motion Counts. Providing a configurable Motion Resolution value is particularly useful for addressing Fractional Unwind applications where it is necessary to have an integer number of Motion Counts per Unwind Cycle.

Valid Motion Unit attribute selections are determined by the Feedback Configuration, Load Type, and Linear Actuator Unit (Lead Unit or Diameter Unit) values according to the following table:

Feedback Configuration	**Load Type**	**Linear Actuator Unit**	**Motion Unit**
No Feedback	Direct Rotary	-	Motor Rev/s
No Feedback	Rotary Transmission	-	Load Rev/s
No Feedback	Linear Actuator	mm/rev | mm	Load m/s
No Feedback	Linear Actuator	inch/rev| inch	Load inch/s
Master Feedback	Direct Rotary	-	Feedback Rev
Master Feedback	Direct Linear	-	Feedback mm
Master Feedback	Rotary Transmission	-	Load Rev
Master Feedback	Linear Actuator	mm/rev | mm	Load mm
Master Feedback	Linear Actuator	inch/rev| inch	Load inch
Motor Feedback	Direct Rotary	-	Motor Rev
Motor Feedback	Direct Linear	-	Motor mm
Motor Feedback	Rotary Transmission	-	Load Rev
Motor Feedback	Linear Actuator	mm/rev |mm	Load mm
Motor Feedback	Linear Actuator	inch/rev | inch	Load inch
Load | Dual Feedback	Direct Rotary	-	Load Rev

Load | Dual Feedback	Direct Rotary	-	Load Rev
Load | Dual Feedback	Direct Linear	-	Load mm
Load | Dual Feedback	Rotary Transmission	-	Load Rev
Load | Dual Feedback	Linear Actuator	mm/rev | mm	Load mm
Load | Dual Feedback	Linear Actuator	inch/rev | inch	Load inch

The Default Motion Resolution value used for scaling factors, Motion Resolution, Conversion Constant, and Position Unwind, depends on the Motion Unit selection according to the following table:

Motion Unit	**Default Motion Resolution**
Motor|Load|Feedback Rev	1,000,000
Motor|Load|Feedback mm	10,000
Motor|Load|Feedback Inch	200,000
Motor|Load|Feedback Rev/s	1,000,000
Motor|Load|Feedback m/s	10,000,000
Motor|Load|Feedback Inch/s	200,000

Travel Range Limit

Because the position parameters are sometimes internally limited to signed 32-bit representation, the Motion Resolution parameter impacts the travel range. In such a case, the equation for determining the maximum travel range based on Motion Resolution is as follows:

- Travel Range Limit (in Motion Units) = +/- 2,147,483,647 / Motion Resolution

Based on a default value of 1,000,000 Motion Counts per Motion Unit, the range limit is 2,147 Motion Units. When the axis position exceeds this value, the position accumulators roll-over, essentially flipping the sign of the axis position value. Motion continuous smoothly through the roll-over but the position values are obviously not contiguous. This is nominal operation in Unlimited Travel Mode. While it is relatively rare for this travel range limitation to present a problem, say in point-to-point positioning applications, it is a simple matter to lower the Motion Resolution to increase the travel range. The downside of doing so is that the position data is then passed with lower resolution that could impact the smoothness of motion. Selecting Limit Travel Mode sets the Motion Resolution value close to the maximum value that complies with the specified Travel Range of the application.

Fractional Unwind

In some cases, however, you may also want to specifically configure Motion Resolution value to handle fractional unwind applications or multi-turn absolute applications requiring cyclic compensation. In these cases where the Position Unwind value for a rotary application does not work out to be an integer number of Motion Counts, the Motion Resolution attribute may be modified to a value that is integer divisible by the Position Unwind value. This is done automatically when selecting the Cyclic Travel Mode.

Motion Polarity

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Required - All	Set/ SSV#	USINT	0	0	1	Enumeration: 0 = Normal Polarity 1 = Inverted Polarity 2-255 = (Reserved)

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

When Motion Scaling Configuration is set for Drive Scaling, Motion Polarity can be used to switch the directional sense of the motion control system. A Normal setting leaves the sign of the motion control command and actual signal values unchanged from their values in the drive control structure. An Inverted setting flips the sign of the command signal values to the drive control structure and flips the sign of the actual signal values coming from the drive control structure. Motion Polarity can therefore be used to adjust the sense of positive direction of the motion control system to agree with the positive direction on the machine.

When the Motion Scaling Configuration is set to Drive Scaling, the Motion Polarity inversion is performed between the CIP Motion Connection interface and the drive control structure. When the Motion Scaling Configuration is set to Controller Scaling, the Motion Polarity inversion is performed exclusively by the controller.

To maintain directional consistency, the signs of all Signal Attribute values read from the drive control structure or being written to the drive control structure are determined by Motion Polarity. A comprehensive list of these Signal Attributes and their access rules is defined in the following table:

ID	Access Rule	Signal Attribute Name
1402+o	Get	Feedback n Position
1403+o	Get	Feedback n Velocity
1404+o	Get	Feedback n Acceleration
62	Get	Registration 1 Positive Edge Position
63	Get	Registration 1 Negative Edge Position
64	Get	Registration 2 Positive Edge Position
65	Get	Registration 2 Negative Edge Position
70	Get	Home Event Position
360	Set*	Controller Position Command - Integer
365	Get	Fine Command Position
366	Get	Fine Command Velocity
367	Get	Fine Command Acceleration

370	Set	Skip Speed 1
371	Set	Skip Speed 2
372	Set	Skip Speed 3
430	Get	Position Command
431	Set*	Position Trim
432	Get	Position Reference
433	Get	Velocity Feedforward Command
436	Get	Position Error
437	Get	Position Integrator Output
438	Get	Position Loop Output
450	Get	Velocity Command
451	Set*	Velocity Trim
452	Get	Acceleration Feedforward Command
453	Get	Velocity Reference
454	Get	Velocity Feedback
455	Get	Velocity Error
456	Get	Velocity Integrator Output
457	Get	Velocity Loop Output
480	Get	Acceleration Command
481	Set*	Acceleration Trim
482	Get	Acceleration Reference
483	Get	Acceleration Feedback
801	Get	Load Observer Acceleration Estimate
802	Get	Load Observer Torque Estimate
490	Get	Torque Command
491	Set*	Torque Trim
492	Get	Torque Reference

493	Get	Torque Reference - Filtered
494	Get	Torque Reference - Limited
821	Get	Total Inertia Estimate
520	Get	Iq Current Command
521	Get	Operative Current Limit
523	Get	Motor Electrical Angle
524	Get	Id Current Reference
525	Get	Id Current Reference
840	Set	Current Disturbance
527	Get	Iq Current Error
528	Get	Id Current Error
529	Get	Iq Current Feedback
530	Get	Id Current Feedback
565	Get	Slip Compensation
600	Get	Output Frequency
601	Get	Output Current
602	Get	Output Voltage
603	Get	Output Power

Motion Polarity can also have an impact on directional position, velocity, acceleration, and torque limit attributes. When the Motion Scaling Configuration is set to Drive Scaling, inverting Motion Polarity requires that positive and negative position, velocity, acceleration*, and torque limit values be both sign inverted and swapped between the CIP Motion Connection interface and the drive's internal control structure.

When the Motion Scaling Configuration is set to Controller Scaling, inverting Motion Polarity requires that positive and negative position, velocity, acceleration, and torque limit attribute values in Motion Control Axis Object be inverted and swapped with the corresponding attributes in the Motion Device Axis Object. For example entering a "Velocity Limit – Positive" value in the controller of 100 revs/sec would result in a "Velocity Limit – Negative" value of -100 revs/sec in the drive device.

A comprehensive list of these Directional Limit Attributes and their access rules is defined in the following table:

ID	Access Rule	Attribute Name
374	Set	Ramp Velocity - Positive

375	Set	Ramp Velocity - Negative
376	Set	Ramp Acceleration
377	Set	Ramp Deceleration
448	Set	Position Limit - Positive
449	Set	Position Limit - Negative
473	Set	Velocity Limit - Positive
474	Set	Velocity Limit - Negative
485	Set	Acceleration Limit*
486	Set	Deceleration Limit*
504	Set	Torque Limit - Positive
505	Set	Torque Limit - Negative

* *Acceleration and Deceleration Limits are unsigned positive values and, therefore, do not need to be sign inverted.*

Position Units

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Required - All	Set	STRING	"Position Units"	-	-	"Revs"

The Position Units string attribute allows user-defined engineering units rather than "counts" to be used for measuring and programming all motion-related values (position, velocity, acceleration, etc). Position Units can be different for each axis and should be chosen for maximum ease of use in the machine application. For example, linear axes might use Position Units of "Inches", "Meters", or "mm" while rotary axes might use Position Units of "Revs" or "Degrees".

The Position Units attribute can support an ASCII text string of up to 32 characters. This string is used by Logix Designer application in the axis configuration dialogs to request values for motion-related parameters in the specified Position Units. In this case, the software limits the maximum string length to 15 characters.

Average Velocity Timebase

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Required - All	Set/ SSV#	REAL	0.25	0.001 (1 coarse update period)	32 (1000 coarse update period)	Sec

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

This attribute determines the period of time over which the system computes Average Velocity for this axis instance.

Range limits based on coarse update period and history array size are ultimately enforced for Average Velocity Timebase attribute by clamping to limit rather than generating a value out of range error. Only if the value is outside the fixed Min/Max limits is an out of range error given.

Conversion Constant

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Required - All	Set/ SSV#	REAL	Default Motion Resolution	10^{-12}	10^{12}	Counts/Position Unit

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

This attribute is used as a scaling factor allowing axis position, velocity, and acceleration attributes to be displayed or configured in the user's preferred units specified by the Position Unit string attribute. Specifically, the Conversion Constant, is used by the motion system to scale the axis position units into motion planner counts and vice versa. The Conversion Constant represents the number of counts of the motion planner per Position Unit.

Position Unwind

Usage	Access	Data Type	Default	Min	Max	Semantics of Values
Required - E	Set/ SSV#	DINT	Default Motion Resolution	1	10^{9}	Counts/Cycle

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

If the axis is configured for cyclic Travel Mode, a value for the Position Unwind attribute is required. This is the value used to perform electronic unwind of the cyclic axis' position. Electronic unwind operation provides infinite position range for cyclic axes by subtracting the position unwind value from both the actual and command position every time the axis completes a machine cycle. To avoid accumulated error due to round-off with irrational conversion constants, the unwind value is expressed as an integer number of feedback counts per cycle.

See also

[Motion Resolution Value Examples]

 How are we doing?