# Motion Axis Gear (MAG)

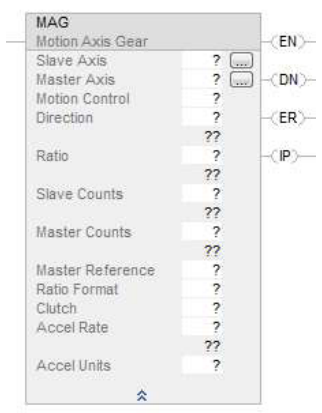
This information applies to the CompactLogix 5370, ControlLogix 5570, Compact GuardLogix 5370, GuardLogix 5570, Compact GuardLogix 5380, CompactLogix 5380, CompactLogix 5480, ControlLogix 5580, and GuardLogix 5580 controllers. Controller differences are noted where applicable.

The Motion Axis Gear (MAG) instruction provides electronic gearing between any two axes in a specified direction and at a specified ratio. When called, the specified Slave Axis is geared to the Master Axis at the specified Ratio (for example, 1.345) or Slave Counts to Master Counts (for example, 1:3). The MAG instruction supports specification of the gear ratio in one of two different formats, Real or Fractional, as determined by the Ratio Format input selection. The direction of Slave Axis motion relative to the Master Axis is defined by a very flexible Direction input parameter. The gearing direction may be explicitly set as the Same or Opposite or set relative to the current gearing direction as Reverse or Unchanged.

**Tip:** The value for Ratio is sign sensitive. The Master Reference selection allows gearing input to be derived from either the Actual or Command position of the Master Axis. When the instruction's Clutch capability is activated the gearing instruction commands the slave axis to accelerate or decelerate at a controlled rate before Locking on to the master axis using the instructions Acceleration value much like the clutch of a car.

## Available Languages

### Ladder Diagram




### Function Block

This instruction is not available in function block.

### Structured Text

MAG(SlaveAxis,MasterAxis,MotionControl,Direction,Ratio,SlaveCounts,MasterCounts,MasterReference,RatioFormat,Clutch,AccelRate,AccelUnits);

## Operands

### Ladder Diagram and Structured Text

| Operand | Type<br><br>**CompactLogix 5370, Compact GuardLogix 5370, Compact GuardLogix 5380, CompactLogix 5380, CompactLogix 5480** | Type<br><br>**ControlLogix 5570, GuardLogix 5570, ControlLogix 5580, and GuardLogix 5580 controllers** | Format | Description |
|---|---|---|---|---|
| Slave Axis | AXIS_CIP_DRIVE<br><br>AXIS_VIRTUAL | AXIS_CIP_DRIVE<br><br>AXIS_VIRTUAL<br><br>AXIS_GENERIC_DRIVE<br><br>AXIS_SERVO<br><br>AXIS_SERVO_DRIVE | Tag | Name of the axis to perform operation on. |
| Master Axis | AXIS_CONSUMED<br>AXIS_VIRTUAL<br><br>AXIS_CIP_DRIVE<br><br>**Tip:** AXIS_CONSUMED is supported by Compact GuardLogix 5580, CompactLogix 5380, and CompactLogix 5480 controllers only. | AXIS_CONSUMED<br>AXIS_VIRTUAL<br><br>AXIS_CIP_DRIVE | Tag | The axis that the slave axis follows. |
| Motion Control | MOTION_INSTRUCTION | MOTION_INSTRUCTION | Tag | Structure used to access instruction status parameters. |

| | | | | |
|---|---|---|---|---|
| Direction | UINT32 | UINT32 | Immediate or Tag | The relative direction that the Slave axis tracks the Master Axis.<br>Select one of following:<br>0 = slave axis moves in the same direction as the master axis<br>1 = slave axis moves in the opposite direction of its current direction<br>2 = slave axis reverses from current or previous<br>3 = slave axis to continue its current or previous direction. |
| Ratio | REAL | REAL | Immediate or Tag | Signed Real value establishing the gear ratio in Slave User Units per Master User Unit. |
| Slave Counts | UINT32 | UINT32 | Immediate or Tag | Integer value representing slave counts used in specifying a Fractional gear ratio. |
| Master Counts | UINT32 | UINT32 | Immediate or Tag | Integer value representing master counts used in specifying a Fractional gear ratio. |
| Master Reference | BOOLEAN | BOOLEAN | Immediate | Sets the master position reference to either Command position or Actual position.<br>0 = Actual – slave axis motion is generated from the current position of the master axis as measured by its encoder or other feedback device.<br>1 = Command – slave axis motion is generated from the desired or commanded position of the master axis. |
| Ratio Format | BOOLEAN | BOOLEAN | Immediate | The desired ratio specification format. Select either:<br>0 = real gear ratio<br>1 = integer fraction of slave encoder counts to master encoder counts. |
| Clutch | BOOLEAN | BOOLEAN | Immediate | When Clutch is enabled, motion control ramps the slave axis up to gearing speed at the instruction's defined Acceleration value. If not enabled, the Slave axis immediately locks onto the Master axis. If the Master Axis is currently moving this condition results in an abrupt uncontrolled acceleration event of the Slave Axis which can cause the axis to fault. Select either:<br>0 = enabled<br>1 = disabled |
| Accel Rate | REAL | REAL | Immediate or Tag | Acceleration rate of the Slave Axis in % or Acceleration Units. It is applied when the Clutch feature is enabled. |
| Accel Units | DINT | DINT | Immediate | The units used to display the Acceleration value. Select either:<br>0 = units per $sec^2$<br>1 = % of maximum acceleration |

See Structured Text Syntax for more information on the syntax of expressions within structured text.

For the operands that require you to select from available options, enter your selection as described below.

| This Operand | Has These Options Which You | |
|---|---|---|
| | **Enter as Text** | **Or Enter as a Number** |
| MasterReference | actual<br>command | 0<br>1 |
| RatioFormat | real<br>fraction_slave_master_counts | 0<br>1 |
| Clutch | enabled<br>disabled | 0<br>1 |
| AccelUnits | unitspersec2<br>%ofmaximum | 0<br>1 |

# MOTION_INSTRUCTION Structure

| Mnemonic | Description |
|---|---|

| | |
|---|---|
| .EN (Enable) Bit 31 | It is set when the rung makes a false-to-true transition and remains set until the servo message transaction is completed and the rung goes false. |
| .DN (Done) Bit 29 | It is set when axis gear has been successfully initiated. |
| .ER (Error) Bit 28 | It is set to indicate that the instruction detected an error, such as if you specified an unconfigured axis. |
| .IP (In Process) Bit 26 | It is set on positive rung transition and cleared if either superseded by another Motion Gear Axes command, or terminated by a stop command, merge, shutdown, or servo fault. |

# Description

The MAG instruction enables electronic gearing between two axes at a specified ratio. Electronic gearing allows any physical axis to be synchronized to the actual or command position of another physical axis at a precise ratio. It provides a direct edge-to-edge lock between the two axes—no maximum velocity, acceleration, or deceleration limits are used. The speed, acceleration, and deceleration of the slave axis is completely determined by the motion of the master axis and the specified gear ratio.

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**Important:** The maximum velocity, acceleration, or deceleration limits established during axis configuration do not apply to electronic gearing.

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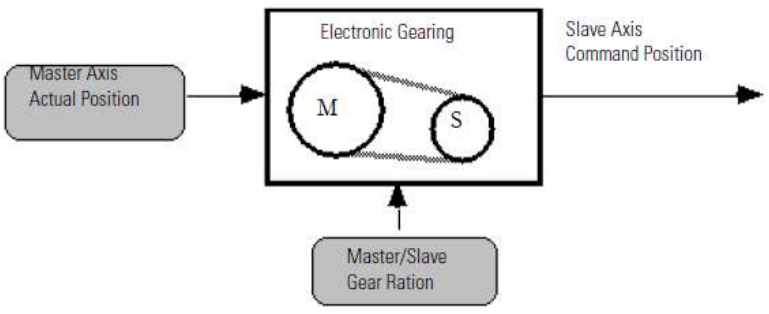
Select or enter the desired Master Axis, Slave Axis, and Direction and enter a value or tag variable for the desired ratio. If an axis is dimmed (gray) or not shown in the Slave Axis pop-up menu, the physical axis is not defined for Servo operation.

If the targeted axis does not appear in the list of available axes, the axis has not been configured for servo operation. Use the Tag Editor to create and configure a new axis.

Electronic gearing remains active through any subsequent execution of jog, or move processes for the slave axis. This allows electronic gearing motions to be superimposed with jog, or move profiles to create complex motion and synchronization.

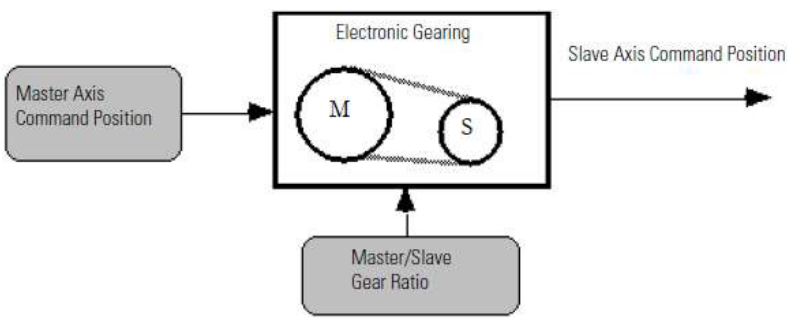
Slaving to the Actual Position When Actual Position is entered or selected as the Master Reference source, the slave axis motion is generated from the actual position of the master axis as shown below.




Actual position is the current position of a physical axis as measured by the axis encoder. This is the only valid selection when the master axis' Axis Type is configured as Feedback Only.

# Slave to the Command Position

When Command Position is entered or selected as the Master Reference source, the slave axis motion is generated from the command position of the master axis as shown below.




Command position (only valid when the master axis' Axis Type is configured as Servo) is the current desired or commanded position for the master axis.

Since the command position does not incorporate any associated following error, external position disturbances, or quantization noise, it is a more accurate and stable reference for gearing. When gearing to the command position of the master, the master axis must be commanded to move to cause any motion on the slave axis.

# Gear in the Same Direction

When Same is selected or entered as the Direction, the slave axis moves in its positive direction at the specified gear ratio when the master axis moves in its positive direction and vice-versa.

# Gear in the Opposite Direction

When Opposite is selected or entered as the Direction, the slave axis moves in its negative direction at the specified gear ratio when the master axis moves in its positive direction and vice-versa.

# Change the Gear Ratio

When Unchanged is selected or entered as the Direction, the gear ratio may be changed while preserving the current gearing direction (same or opposite). This is useful when the current direction is not known or not important.

# Reverse the Gearing Direction

When Reverse is selected or entered as the Direction, the current direction of the electronic gearing is changed from same to opposite or from opposite to same. This is very useful for winding applications where the gear ratio must be reversed at each end of the wind.

# Real Number Gear Ratio

When Ratio Format is selected or entered as Real, the gear ratio is specified as a real number or tag variable with a value between 0.00001 and 9.99999 (inclusive) representing the desired ratio of slave axis position units to master axis position units. A gear ratio expressed this way is easy to interpret since it is defined in the axes' configured position units.

# Fraction Gear Ratios

When Ratio Format is selected or entered as Fraction, the gear ratio is specified as a pair of integer numbers or tag variables representing the ratio between the number of slave axis feedback counts and the number of master axis feedback counts. See The Tag variable Builder earlier in this manual for information on tag variables.

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**Important:** The Conversion Constant entered as part of the axis configuration procedure is not used when the Ratio Format for the MAG instruction is specified as a Fraction.

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If your gear ratio cannot be exactly expressed as a real number with a maximum of five digits to the right of the decimal point, use Fraction as the Ratio Format.

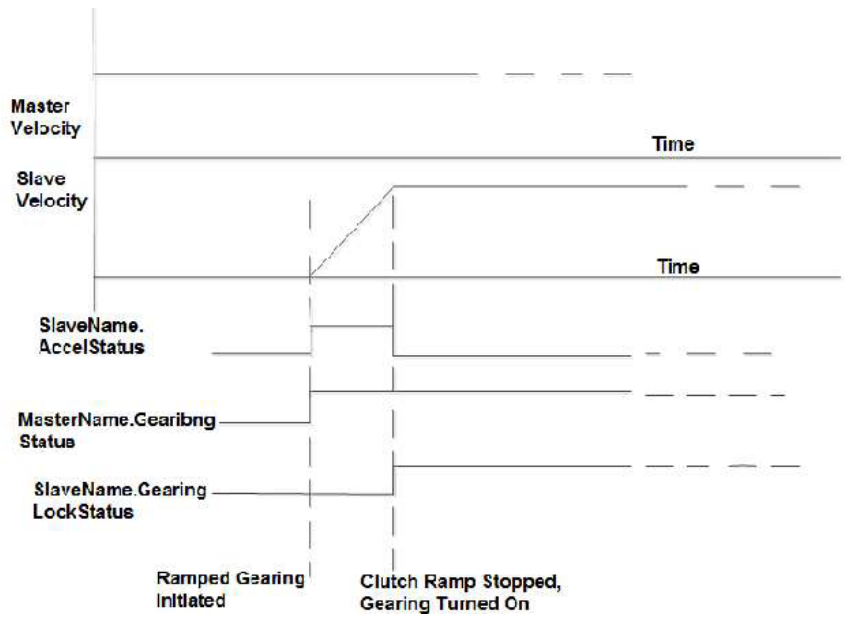
Specifying the gear ratio as a fraction allows the direct implementation of irrational gear ratios (such as 1/3) with no accumulated positioning errors or round off. Since the master and slave count values do not use the axis conversion constants and because they are integers, the actual gear ratio relationship between the slave and master axes exactly match the specified ratio.

For example, the irrational gear ratio of 1/3 can be equivalently specified as 1 slave count to 3 master counts, 10 slave counts to 30 master counts, 3 slave counts to 9 master counts.

# Clutch

When the Clutch check box is checked, the slave axis accelerates or decelerates to the speed that it would be moving if it were currently geared to the selected master axis at the specified gear ratio and direction using a trapezoidal velocity profile (linear acceleration or deceleration). Once the slave axis has reached the gearing speed, electronic gearing is automatically activated according to the other selections. Enter the desired Accel Rate as a percentage of the current configured maximum acceleration value or directly in the configured user units for acceleration.

This clutch function works much like the clutch in a car, allowing the slave axis to be smoothly engaged to the master axis as shown below.




# Clutch Function

Using the clutch feature avoids the uncontrolled acceleration or deceleration that results when electronic gearing is enabled while the master axis is moving. The clutch feature can also be used to merge gear ratio changes on-the-fly, even changes in direction. The motion controller automatically ramps the slave axis to the speed implied by the master axis at the new ratio and/or direction.

The operation of the clutch ramp generator has no affect on jog or move processes that might be in progress on the slave axis.

# Changing Master Axes

The master axis for electronic gearing can be changed at any time, even while gearing is currently enabled. However, since it is possible to have electronic gearing enabled on more than one axis at a time, if a Servo master axis and slave axis are reversed, the axes become cross-coupled and unexpected motion may result.

For example, if you are gearing Axis 0 to Axis 1 (defined as a Servo axis) and then want to change to gearing Axis 1 to Axis 0, you must first disable gearing on Axis 0 (see Disable Gearing later in this section). This is because specifying Axis 1 as the slave axis with Axis 0 as the master axis does not automatically disable Axis 0 from being a slave axis with Axis 1 as the master axis.

# Move While Gearing

An incremental MAM instruction may be used for the slave axis (or master axis if the Axis Type is configured as Servo) while the electronic gearing is enabled. This is particularly useful to accomplish phase advance/retard control. The incremental move distance can be used to eliminate any phase error between the master and the slave, or to create an exact non-zero phase relationship. Incremental MAM instruction may also be used in conjunction with electronic gearing to compensate for material slip.

Normally a gear ratio of 1 is used with phase adjustment. A 1:1 ratio ensures that the computed phase error does not change before performing the move to correct it. Electronic gearing is not normally used with absolute moves, since the ultimate endpoint is not predictable.

To successfully execute a MAG instruction, the targeted axis must be configured as a Servo Axis Type and the axis must be in the Servo On state. If any of these conditions are not met than the instruction errors.

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**Important:** The MAG instruction execution completes in a single scan, thus the Done (.DN) bit and the In Process (.IP) bit are set immediately. The In Process (.IP) bit remains set until the initiated Gear process is superseded by another MAG instruction, or terminated by a Motion Axis Stop command, Merge operation, or Servo Fault Action.

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In this transitional instruction, the relay ladder, toggle the Rung-condition-in from cleared to set each time the instruction should execute.

## Affects Math Status Flags

No

## Major/Minor Faults

None specific to this instruction. See Common Attributes for operand-related faults

## Execution

## Ladder Diagram

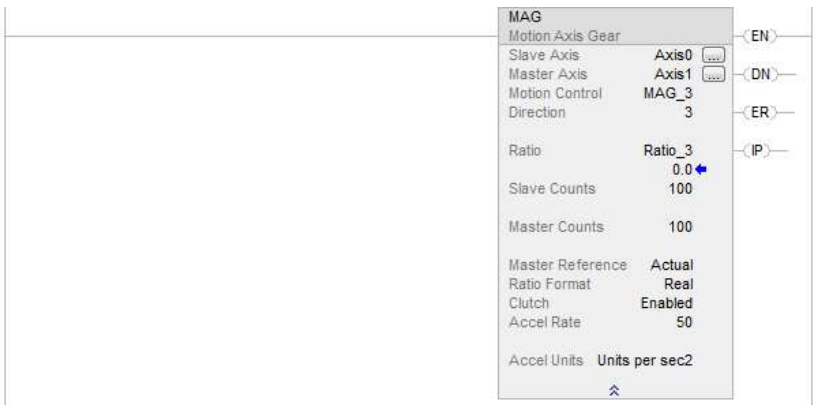
| Condition/State | Action Taken |
|---|---|
| Prescan | The .EN, .DN, .ER, and .IP bits are cleared to false. |
| Rung-condition-in is false | The .EN bit is cleared to false if either the .DN or .ER bit is true. |
| Rung-condition-in is true | The .EN bit is set to true and the instruction executes. |
| Postscan | N/A |

## Structured Text

| Condition/State | Action Taken |
|---|---|
| Prescan | See Prescan in Ladder Diagram table |
| Normal execution | See Rung-condition-in is false, followed by rung is true in the Ladder Diagram table. |
| Postscan | See Postscan in Ladder Diagram table. |

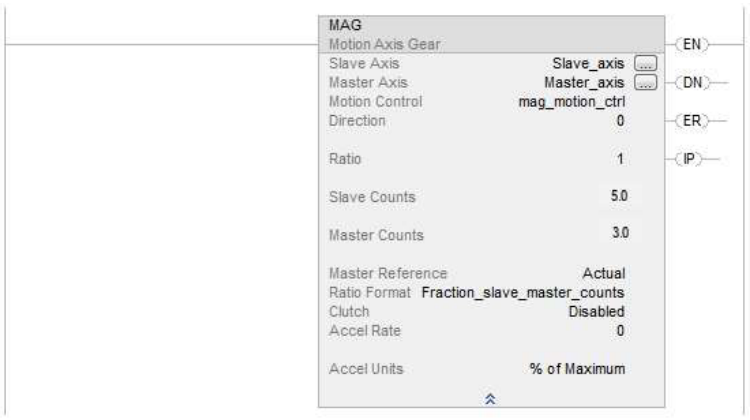
## Examples

### Example 1




### Example 2

This example increases the number of operands that require data conversion.




## See also

Structured Text Syntax

MAG Flow Chart (True)

Motion Error Codes (.ERR)

Motion Move Instructions

Common Attributes



How are we doing?