**Application Technique**

Original Instructions

# Motor Nameplate Datasheet Entry for Custom Motor Applications

Catalog Numbers

Kinetix® 5300 servo drives:

198-C1004-ERS, 2198-C1007-ERS, 2198-C1015-ERS, 2198-C1020-ERS, 2198-C2030-ERS, 2198-C2055-ERS, 2198-C2075-ERS, 2198-C4004-ERS, 2198-C4007-ERS, 2198-C4015-ERS, 2198-C4020-ERS, 2198-C4030-ERS, 2198-C4055-ERS, 2198-C4075-ERS

Kinetix 5500 servo drives:

2198-H003-ERS, 2198-H008-ERS, 2198-H015-ERS, 2198-H025-ERS, 2198-H040-ERS, 2198-H070-ERS, 2198-H003-ERS2, 2198-H008-ERS2, 2198-H015-ERS2, 2198-H025-ERS2, 2198-H040-ERS2, 2198-H070-ERS2, 2198-CAPMOD-1300

Kinetix 5700 servo drives:

2198-D*xxx*-ERS3, 2198-S*xxx*-ERS3, 2198-D*xxx*-ERS4, 2198-S*xxx*-ERS4

# Summary of Changes

This publication contains the following new or updated information. This list includes substantive updates only and is not intended to reflect all changes.

| Topic | Page |
|---|---|
| Added Kinetix 5300 and Kinetix 5500 information. | Throughout |
| Edited the entire About this Publication section, including adding the Kinetix Drives and Motors, Custom Motor Strategy, Custom Motor Files, and Intelligent Feedback Devices subsections. | 3 |
| Edited the majority of the Motor Nameplate Datasheet Entry Implementation Guidelines section. | 4 |
| Edited statement about completing the entire setup of an AXIS_CIP_DRIVE in the Motor Nameplate Datasheet Entry Overview section. | 4 |
| Updated screen captures of the Studio 5000 Logix Designer software to version 34. | Throughout |
| Added the Axis Configuration Compatibility Matrix table. | 5 |
| Add the application examples to the Position Loop with Motor Feedback section. | 6 |
| Added a statement about the usage of a torque loop to the Frequency Control with No Feedback section. | 7 |
| Changed the figure title for the Motor Type screen captures in the Motor Category section. | 7 |
| Added details to the IMPORTANT table about the Rotary Interior Permanent Magnet motor type. | 7 |
| Changed the motor type attribute definitions. | 12 |
| Added a description of asynchronous speed to the Rated Speed Calculations section. | 14 |
| Made edits throughout the Generic I2T section. | 15 |
| Added the IMPORTANT table and additional paragraphs to the Thermally Characterized Motor Model section. | 15 |
| Changed the rotary induction motor model attribute definitions. | 18 |
| Changed the permanent-magnet motor model attribute definitions. | 19 |
| Added content throughout the Dynamic Motor Test section. | 21 |
| Added Table 8 through Table 16 to the Configure Motor Feedback section. | 22…24 |
| Rewrote the entire Configure the Universal Feedback Port section. | 24…28 |
| Rewrote the entire Configure the DSL Feedback Port section. | 28 |
| Changed Hookup Test definitions. | 29 |
| Added Hookup Test motor type recommendations. | 29 |
| Added the conditions required to start the commutation test. | 30 |
| Added Self-Sense to the commutation alignment options. | 31 |
| Changed the commutation alignment definitions. | 31 |
| Made multiple edits to the Basic Volts/Hertz Method section. | 32 |
| Changed the description of the conditions in which Sensorless Vector Economy control method is available. | 35 |
| Changed the introductory text for the Frequency Control Method Guidelines table. | 37 |
| Reformatted the Application Matrix table. | 37 |
| Made changes to text throughout the Configure the Motor > Analyzer Category procedure. | 42 |
| Changed the statement about Digital AqB in step 4a of the Induction Motor With Encoder Example. | 44 |
| Made changes throughout the Induction Motor With Encoder Example, Axis Properties - Online Tasks section. | 47…51 |
| Added Kinetix 5300 content to the Rotary Surface Permanent-magnet Motor Example section. | 51 |
| Made changes throughout the Rotary Surface Permanent-magnet Motor Example, Axis Properties - Online Tasks section. | 55…59 |
| Added Kinetix 5300 content to the Linear Surface Permanent-magnet Motor Example section. | 59 |
| Made changes throughout the Linear Surface Permanent-magnet Motor Example, Axis Properties - Online Tasks section. | 63…68 |
| Made changes throughout the Motor > Analyzer Category Tests section. | 69 |
| Made changes throughout the Static Motor Test section. | 70 |
| Made changes throughout the Dynamic Motor Test section. | 71 |
| Made changes throughout the Hookup Tests Category section. | 71 |
| Made changes throughout the Autotune Test section. | 72 |
| Mad changes throughout the Motion Direct Commands section. | 73 |

# About this Publication

This publication provides an in-depth discussion on the use of nameplate data entry for custom induction motors and permanent-magnet motors that are used in applications with Kinetix 5300, Kinetix 5500, and Kinetix 5700 servo drives.

Kinetix 5300, 5500, and 5700 drives (integrated motion on EtherNet/IP™ capable) are primarily used with pre-determined cataloged motors selected using a dropdown menu. These motors, drives, and feedback devices are pre-tested and characterized to determine the limits of performance and operation. This process is part of the simplicity of the Kinetix integrated motion axis.

When you are using a custom motor and feedback device with a Kinetix 5300, 5500, or 5700 drive (integrated motion on Ethernet/IP capable), you must attempt to determine this axis characterization. Determine the axis characterization by using the nameplate and testing methods that are explained in this publication.

## Kinetix Drives and Motors

The Studio 5000 Logix Designer® application was designed with embedded motion control capabilities, including an axis configuration that uses Kinetix Drives and Motors with a catalog number dropdown selection process. This functionality creates an accurate, simple motion solution with many benefits, including easy replacement, limit protection, simple configuration, and modular programming. Rockwell Automation has characterized and optimized the appropriate motor and drive combinations that are available to be selected in the Studio 5000 Logix Designer application using the Axis Properties. These drive and motor combinations, and their data, are used to provide the best performance and flexibility for your application.

## Custom Motor Strategy

Rockwell Automation strives to provide solutions including all types of actuators into our product portfolio. Rockwell Automation and our Technology Partners serve many custom motor types, applications, and environments. Rockwell Automation uses our custom motor nameplate entry and motor file (customer motor file or CMF) via Axis Properties to address any custom motors that are not included in our product portfolio.

Some machinery uses specialized or application-specific actuators. Rockwell Automation attempts to support those actuators using Kinetix drives and ControlLogix® controllers. Because of the advantages of using Kinetix Integrated Motion, it has become a powerful solution for unique applications and their actuators.

## Custom Motor Files

A custom motor file (CMF) is used for legacy motors, Technology Partner motors, and custom Kinetix motors. Rockwell Automation creates CMFs to easily integrate actuators that are provided by our Technology Partners into the Kinetix Integrated Motion solution. Partner-provided actuator characteristics are combined with data from an intelligent feedback device (where applicable) to provide an optimized solution that is comparable to the Kinetix drive and motor solution. If you are using the custom motor file, an import tool has been created to allow the custom motor to be added to the catalog number dropdown list in the Studio 5000 Logix Designer application.

## Intelligent Feedback Devices

Kinetix motors that use intelligent feedback devices are programmed by Rockwell Automation to provide tag data including motor ID, motor characteristics, commutation test data, thermal information, and high-resolution motor position (both real-time and absolute position retention capability). This data comes in the form of a binary encoder file, which can be of file type ".blb", ".tef", or other types. This file resides in the feedback device and is used by Rockwell Automation when the motor is manufactured or refurbished. A feedback device that contains a binary encoder file that has been programmed with this data is called a 'programmed' feedback device.

Kinetix motors with Hiperface feedback use a binary encoder file. It is referred to as a 'blb' binary file.

Kinetix drives can support intelligent feedback devices that are not 'programmed'. These non-programmed feedback devices can be used with custom motors. However, non-programmed feedback devices only provide basic motor functionality, that is, high-resolution motor position (both real-time and absolute retention capability). In this case, commutation and all other motor data must come from the nameplate data entries. This combined drive and motor data must be tested by the user because no other motor characteristic or thermal data is available from the non-programmed feedback device. Non-programmed intelligent feedback devices still use the binary or ".blb" files, but the files are blank. If any programming is present on the encoder (not Kinetix motor data), the drive will fault. See Table 2 on page 5 for feedback device compatibility and correct usage. Third party drive and motors typically use motor feedback devices that are programmed. Unless these feedback devices are provided by a Technology Partner, these third party motors and feedback devices cannot be used until the feedback device's memory is cleared or a non-programmed feedback device is used.

## Motor Nameplate Datasheet Entry Implementation Guidelines

The following guidelines apply for motor nameplate datasheet entry with Kinetix 5300, 5500, and 5700 drives:

- The motor must have a 200V-class or 400V-class input power rating and match the current/power ratings of the Kinetix 5300, 5500, or 5700 inverter.
- Induction motors do not use motor feedback devices when they are configured as Open Loop and use the Frequency Control mode.
- Induction motors and permanent-magnet motors (rotary and linear surface permanent-magnet) can be used with motor feedback devices when the drive is in Position, Velocity, or Torque Loop mode.
  - For motor feedback types accepted by Kinetix 5700 drives, see the Axis Configuration Compatibility Matrix (Table 2 on page 5), or the Feedback Specifications in the Kinetix 5700 Servo Drives User Manual, publication 2198-UM002.
- Motors with programmed feedback devices cannot be used with nameplate datasheet entry.
- This document applies to integer-based pole-pitch linear motor layout. Fractional pole pitch is not directly supported and if such an opportunity exists, contact your local Rockwell Automation® sales office.

| **IMPORTANT** | Interior permanent magnet (IPM) motors are listed as an available motor type for nameplate datasheet entry. Currently, the IPM nameplate motor data entries should only be used with non-cataloged Kinetix motors (for example, VPC-series or MMA-series motors). |
|---|---|

- Obtain the motor-equivalent circuit diagram from the motor manufacturer for proper evaluation of motor data and performance expectations. If this data is not available, or contains different units of measure, use the Motor > Analyzer Category section for an estimation of these values.
- Choose your drive.
  - To choose your drive, we recommend that you use the FactoryTalk® Motion Analyzer, the online system sizing and selection tool available at https://motionanalyzer.rockwellautomation.com. Alternately, you can download the FactoryTalk Motion Analyzer from the Product Compatibility Download Center (PCDC), using the search term "FactoryTalk Motion Analyzer".
  - Other resources that can be used when choosing your drive include the documents in Additional Resources on page 75.

## Motor Nameplate Datasheet Entry Overview

For non Allen-Bradley® motors, the nameplate datasheet specifications for your motor must be entered into the Studio 5000 Logix Designer application manually. In this publication, Studio 5000 Logix Designer version 34 was used. The purpose of this publication is to explain how to navigate the Logix Designer application and know where to enter the data. These examples include, induction motors, rotary surface permanent-magnet (SPM) motors, and linear SPM motors.

This publication defines only the Axis Properties categories specific to nameplate datasheet entry. To complete the entire setup of an AXIS_CIP_DRIVE that is used with Studio 5000 Logix Designer, refer to the Integrated Motion on EtherNet/IP Configuration and Startup User Manual, publication MOTION-UM003.

| **IMPORTANT** | Axis configuration is dependent on your motor type and whether motor feedback is used in the application. |
|---|---|

**Table 1 - AXIS_CIP_DRIVE Default Categories**

| Motor Type | Frequency Control | Position Loop | Velocity Loop | Torque Loop |
|---|---|---|---|---|
| Rotary induction motor with feedback | – | X | X | X |
| Rotary SPM motor with feedback | – | X | X | X |
| Linear SPM motor with feedback | – | X | X | X |
| Rotary induction motor with no feedback | X | – | – | – |

Table 2 shows Kinetix drive compatibility with motor types that use the custom motor entry with Studio 5000 Logix Designer Axis Properties.

**Table 2 - Axis Configuration Compatibility Matrix**

| | General > Axis Configuration | Motor Type | | | Frequency Control Method (Open Loop) | | | Closed Loop Type | | | Supported Feedback Types | | | | | | | | Commutation Alignment | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rotary Induction | Rotary Surface Permanent Magnet (SPM) | Linear Surface Permanent Magnet (SPM) | Volts/Hz | Fan/Pump Volts/Hz | Sensorless Vector | Position Loop | Velocity Loop | Torque Loop | Digital AqB (Generic TTL) | Digital AqB with UVW (Generic TTL) | Hiperface (not programmed) | Generic Sine/Cosine Incremental | Generic Sine/Cosine Incremental with UVW | EnDat Sin/Cos (not programmed) | EnDat Digital | Nikon Serial | Self Sense | Controller Offset |
| Kinetix 5300 | Frequency Control | x | – | – | x | x | x | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | Closed Loop Control | x | – | – | – | – | – | x | x | x | x | – | x | x | – | – | – | – | – | – |
| | | – | x | – | – | – | – | x | x | x | – | x | x | – | x | – | – | – | – | x |
| | | – | x | – | – | – | – | x | x | x | x | – | – | x | – | – | – | – | x | – |
| | | – | – | x | – | – | – | x | x | x | – | x | x | – | x | – | – | – | – | x |
| | | – | – | x | – | – | – | x | x | x | x | – | – | x | – | – | – | – | x | – |
| Kinetix 5500 | Frequency Control | x | – | – | x | x | x | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | Closed Loop Control | – | – | x | – | – | – | x | x | x | – | – | x | – | – | – | – | – | – | x |
| Kinetix 5700 | Frequency Control | x | – | – | x | x | x | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | Closed Loop Control | x | – | – | – | – | – | x | x | x | x | – | x | x | – | x | – | – | – | – |
| | | – | x | – | – | – | – | x | x | x | x | – | – | x | – | – | – | – | x | – |
| | | – | x | – | – | – | – | x | x | x | – | x | x | – | x | x | – | – | – | x |
| | | – | – | x | – | – | – | x | x | x | x | – | – | x | – | – | – | – | x | – |
| | | – | – | x | – | – | – | x | x | x | – | x | x | – | x | x | – | – | – | x |

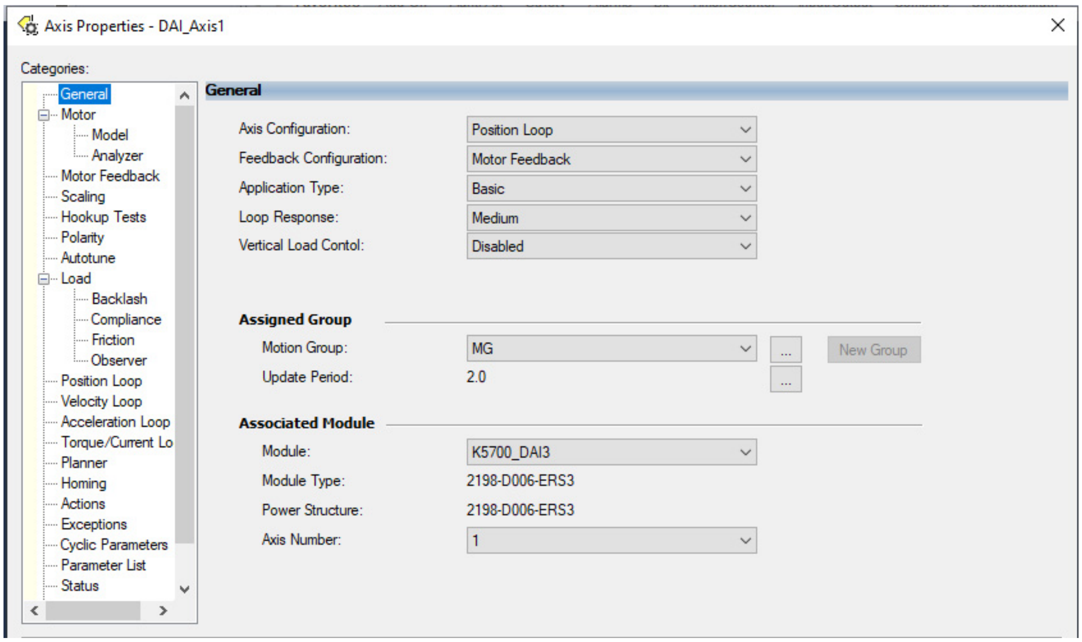
# General Category

Once your axis is configured in the Motion Group, you can configure the axis and feedback configuration types from the General category. In the Controller Organizer, right-click an axis and choose Properties. General is the default category and Position Loop is the default Axis Configuration.

## Position Loop with Motor Feedback

The Position Loop axis configuration is a fully positioning axis. The Position Loop axis configuration uses a motor-mounted feedback device (typically installed on the rear of the motor) to close position, velocity, and torque loops. This axis type can be used for a tracking application, or a point-to-point application, for example.

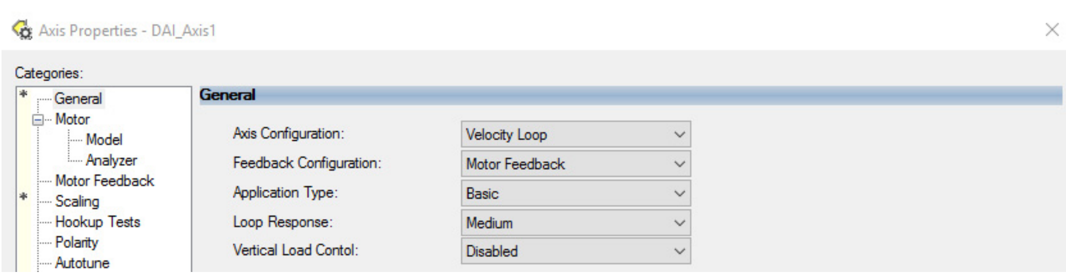
### Figure 1 - Position Loop with Motor Feedback Axis Properties




## Velocity Loop with Motor Feedback

From the Axis Configuration dropdown menu, choose Velocity Loop. Velocity loop can be used in a constant speed application such as an in-feed conveyor to a processing system.

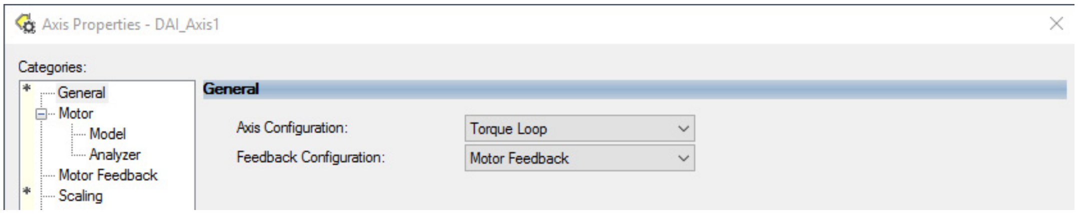
### Figure 2 - Velocity Loop with Motor Feedback Axis Properties



## Torque Loop with Motor Feedback

From the Axis Configuration dropdown menu, choose Torque Loop. When using torque loop with motor feedback, the Application Type and Loop Response are not present. This is because the drive is only responsible for the torque (current) loop when no motor tuning in velocity or position loop control is required.

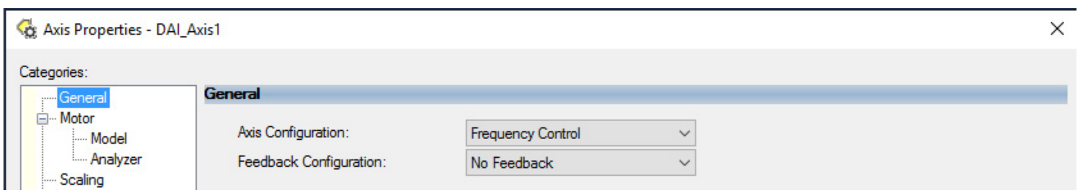
**Figure 3 - Torque Loop with Motor Feedback Axis Properties**




## Frequency Control with No Feedback

From the Axis Configuration dropdown menu, choose Frequency Control. In Frequency Control mode, the Logix Designer application does not include a feedback option. Frequency Control mode is used for open-loop Basic Volts/Hertz, Fan/Pump Volts/Hertz, or Sensorless Vector control. Application Type or Loop Response attributes are available only with a closed loop axis with adjustable gains for performance. The torque loop can be used to provide a set amount of torque for applications like web control or tension loops.

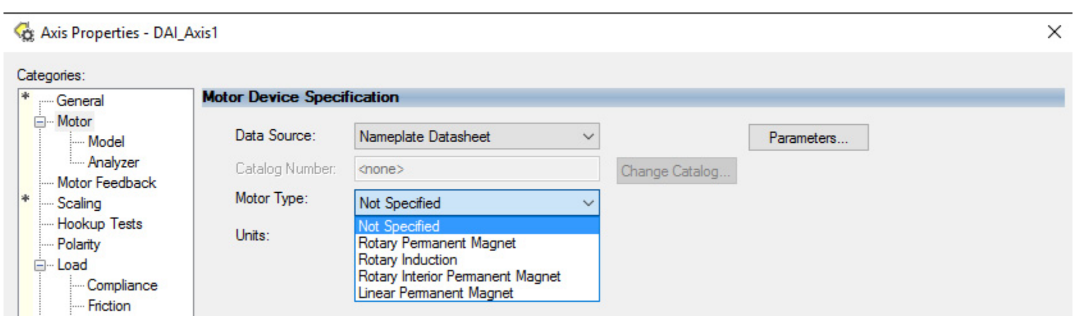
**Figure 4 - Frequency Control with No Feedback Axis Properties**




# Motor Category

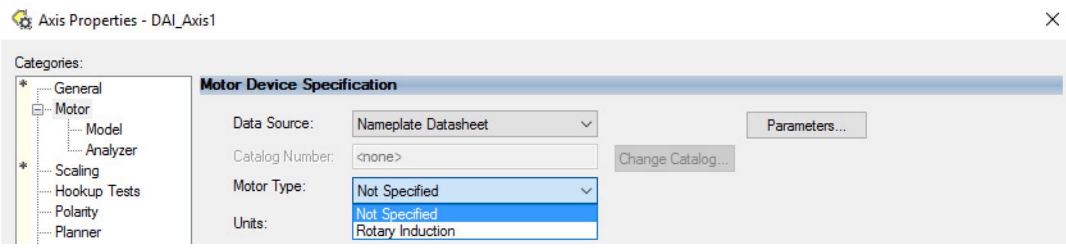
The Motor Type dropdown menu selection is consistent with the axis configuration selection. In position, velocity or torque loop axis configuration, you can select from Rotary Permanent Magnet, Rotary Induction, Rotary Interior Permanent Magnet, and Linear Permanent Magnet motor types.

**Figure 5 - Motor Type (Rotary Induction, Rotary Permanent Magnet, Rotary Interior Permanent Magnet, and Linear Permanent Magnet)**




| | |
|---|---|
| **IMPORTANT** | Rotary induction motors that have motor mounted feedback devices and are configured for Frequency Control mode do not use the feedback device. Rotary Interior Permanent Magnet (IPM) motor is listed as an available motor type for nameplate datasheet entry. Currently, the IPM nameplate motor data entries should only be used with non-cataloged Kinetix motors (for example, VPC-series or MMA-series motors). |

**Figure 6 - Motor Category (Frequency Control)**

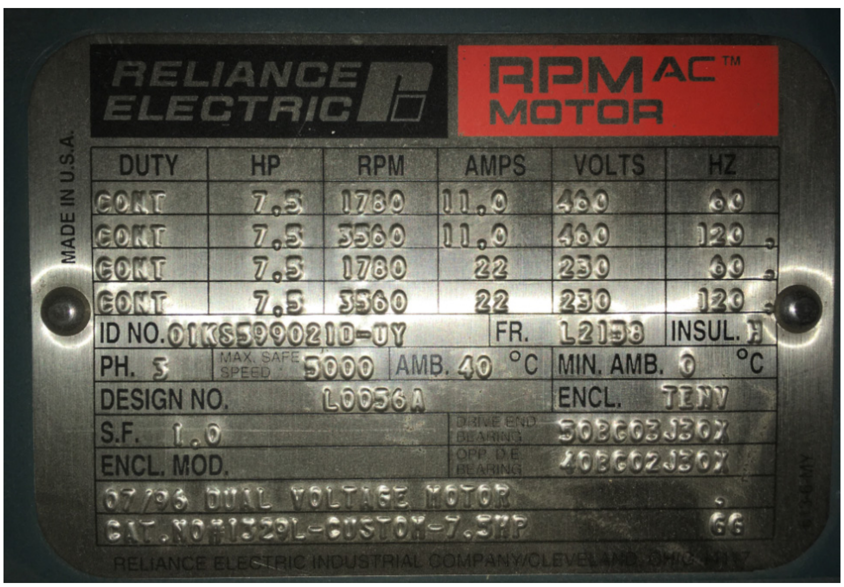



## Motor Nameplates and Performance Datasheets

The typical rotary induction motor nameplate generally includes all required motor specifications. If not, contact the rotary induction motor vendor and request the motor performance datasheet. We recommend that you obtain the motor performance datasheet to compare with the Motor > Analyzer test results. This data entry is critical for rotary induction motor performance.

| | |
|---|---|
| **IMPORTANT** | If obtaining the motor datasheet from the manufacturer is difficult, we recommend that you contact the system integrator/OEM to see if they know where to locate the data. |

**Figure 7 - Rotary Induction Motor Nameplate Example**



### Figure 8 - Rotary Induction Motor Performance Datasheet Example

| HP | kW | SYNC. RPM | F.L RPM | Frame | Enclosure | KVA CODE | DESIGN |
|---|---|---|---|---|---|---|---|
| 7.5 | 5.6 | 1800 | 1780 | L2158 | TENV | H | A |

| PH | Hz | Volts | FL AMPS | START TYPE | DUTY | INSL | S.F. | AMB °C | ELEVATION |
|---|---|---|---|---|---|---|---|---|---|
| 3 | 60 | 460 | 10.71 | INVERTER ONLY | CONTINUOUS | H | 1.0 | 40 | 3300 |

| FULL LOAD EFF: 84 | 3/4 LOAD EFF: 82.5 | 1/2 LOAD EFF: 78.5 | GTD. EFF | ELEC. TYPE | NO LOAD AMPS |
|---|---|---|---|---|---|
| FULL LOAD PF: 0.753 | 3/4 LOAD PF: 0.66 | 1/2 LOAD PF: 0.51 | 81.5 | SQ CAGE INV DUTY | 6.79 |

| F.L. TORQUE | LOCKED ROTOR AMPS | L.R. TORQUE | B.D. TORQUE | F.L. RISE °C |
|---|---|---|---|---|
| 23.01 LB-FT | 30 / 15 | 82.84 LB-FT 360% | 115.05 LB-FT 500% | 65 |

| SOUND PRESSURE @ 3 FT. | SOUND POWER | ROTOR WK^2 | MAX. WK^2 | SAFE STALL TIME | STARTS/ HOUR | APPROX MOTOR WGT |
|---|---|---|---|---|---|---|
| 62 dBA | 72 dBA | 1.69 LB-FT^2 | 0 LB-FT^2 | 0 SEC. | 0 | 42 LBS. |

EQUIVALENT WYE CKT. PARAMETERS (OHMS PER PHASE)

| R1 | R2 | X1 | X2 | XM |
|---|---|---|---|---|
| 0.345 | 0.240 | 1.63 | 2.26 | 41.4 |

| RM | ZREF | XR | TD | TD0 |
|---|---|---|---|---|
| 132.8 | 284 | 1.7 | 0.0071 | 0.136 |

These datasheets are sometimes called “certification data sheets”, and contain typical motor performance data. Torque/speed curves, sometimes referred to as motor electrical-circuit diagrams, are included. We recommend sending examples like the one in Figure 9 on page 10 to your motor supplier to receive all the information you are likely to need.

## Figure 9 - Permanent Magnet Motor Certification Datasheet

### CERTIFICATION DATA SHEET

| | | | |
|---|---|---|---|
| **Model#:** | 213TPFSA10096 A | **WINDING#:** | PM21310001 NONE 1 |
| **CONN. DIAGRAM:** | A-EE7300T | **ASSEMBLY:** | F1/F2 CAPABLE |
| **OUTLINE:** | B-SS89934-912 | | |

### TYPICAL MOTOR PERFORMANCE DATA

| HP | KW | SYNC. RPM | F.L. RPM | FRAME | ENCLOSURE | KVA CODE | DESIGN |
|---|---|---|---|---|---|---|---|
| 7 1/2 | 5.60 | 1800 | 1800 | 213TC | TEFC | N/A | PM |

| PH | Hz | VOLTS | FL AMPS | START TYPE | DUTY | INSL | S.F | AMB°C | ELEVATION |
|---|---|---|---|---|---|---|---|---|---|
| 3 | 150 | 460 | 9.4 | INVERTER ONLY | CONTINUOU S | H1 | 1.0 | 40 | 3300 |

| FULL LOAD EFF: 93 | 3/4 LOAD EFF: - | 1/2 LOAD EFF: - | GTD. EFF | ELEC. TYPE | NO LOAD AMPS |
|---|---|---|---|---|---|
| FULL LOAD PF: 80 | 3/4 LOAD PF: - | 1/2 LOAD PF: - | 93 | SQ CAGE INV DUTY | 1 |

| F.L. TORQUE | LOCKED ROTOR AMPS | L.R. TORQUE | B.D. TORQUE | F.L. RISE°C |
|---|---|---|---|---|
| 21.9 LB-FT | - | - LB-FT - | - LB-FT - | 60 |

| SOUND PRESSURE @ 3 FT. | SOUND POWER | ROTOR WK^2 | MAX. WK^2 | SAFE STALL TIME | STARTS /HOUR | APPROX. MOTOR WGT |
|---|---|---|---|---|---|---|
| 62 dBA | 72 dBA | 0.54 LB-FT^2 | 0 LB-FT^2 | 0 SEC. | 0 | 130 LBS. |

### EQUIVALENT WYE CKT.PARAMETERS (OHMS PER PHASE)

| R1 | R2 | X1 | X2 | XM |
|---|---|---|---|---|
| 0 | 0.4 | 10.5 | 12.9 | 224 |

| RM | ZREF | XR | TD | TD0 |
|---|---|---|---|---|
| 0 | 1 | 0 | 0 | 0 |

### *** SUPPLEMENTAL INFORMATION ***

| DE BRACKET TYPE | ODE BRACKET TYPE | MOUNT TYPE | ORIENTATION | SEVERE DUTY | HAZARDOUS LOCATION | DRIP COVER | SCREENS | PAINT |
|---|---|---|---|---|---|---|---|---|
| C-FACE | STANDARD | RIGID | HORIZONTAL | PREMIUM SEVERE DUTY | NONE | FALSE | NONE | BLACK EPOXY |

| BEARINGS | | GREASE | SHAFT TYPE | SPECIAL DE | SPECIAL ODE | SHAFT MATERIAL | FRAME MATERIAL |
|---|---|---|---|---|---|---|---|
| DE | OPE | | | | | | |
| BALL | BALL | STANDARD | T | NONE | NONE | STANDARD | CAST IRON |
| 6309 | 6208 | | | | | | |

| THERMO-PROTECTORS | | | | THERMISTORS | CONTROL | SPACE /n HEATERS |
|---|---|---|---|---|---|---|
| THERMOSTATS | PROTECTORS | WDG RTDs | BRG RTDs | | | |
| TSTATS 140(N/C) | NOT | NONE | NONE | NONE | FALSE | NONE VOLTS |

## Motor Nameplate Datasheet Phase-to-phase Parameters

Enter phase-to-phase parameters in the Axis Properties > Motor category. These parameters define speed, torque, and overload performance characteristics. The Motor Type dropdown menu selection is consistent with the axis configuration selection. In position, velocity, or torque loop axis configuration, you can select from Rotary Permanent Magnet, Rotary Induction, and Linear Permanent Magnet motor types. See Table 2 on page 5 for the compatible settings and motor types. See Figure 10 through Figure 12 for examples of phase-to-phase parameter entry for specific motor types. See Table 3 on page 12 for definitions of the motor type attributes.

**Figure 10 - Rotary Induction Motor Type Example**

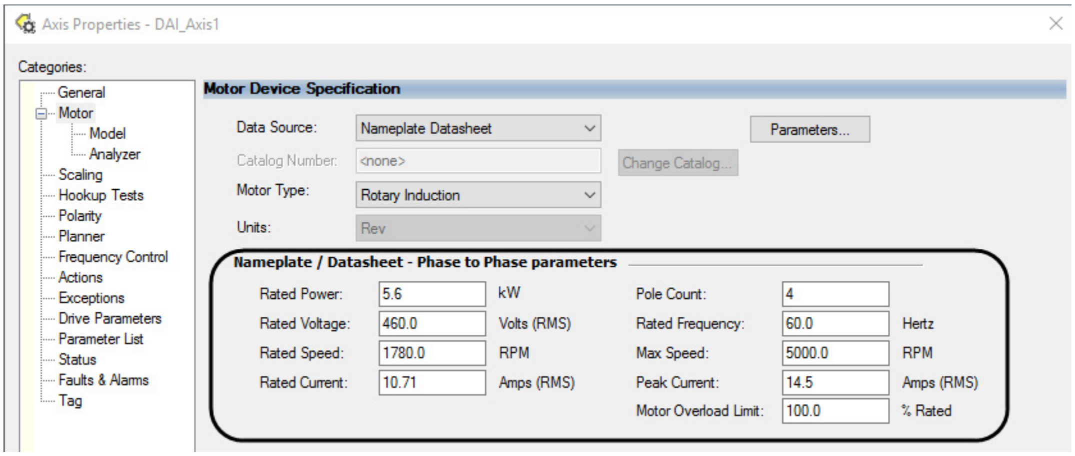



**Figure 11 - Rotary Permanent-magnet Motor Type Example**

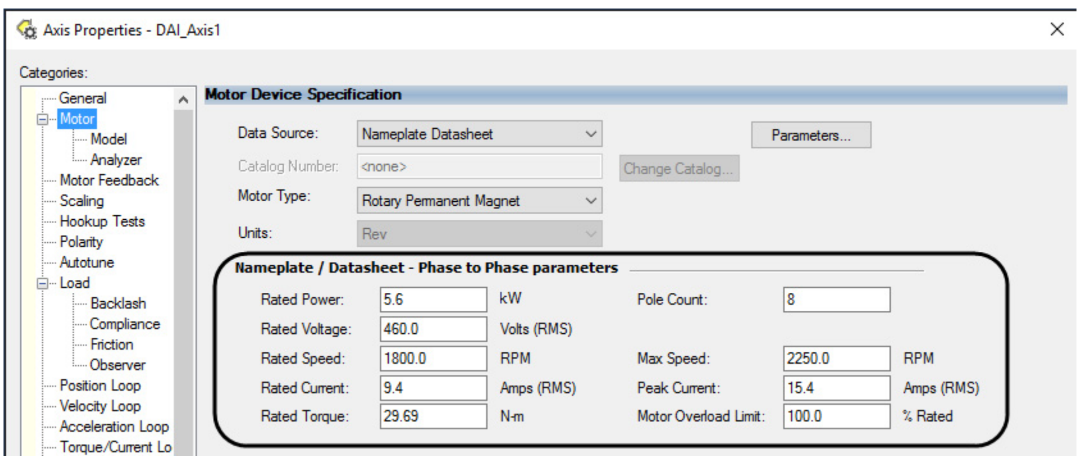
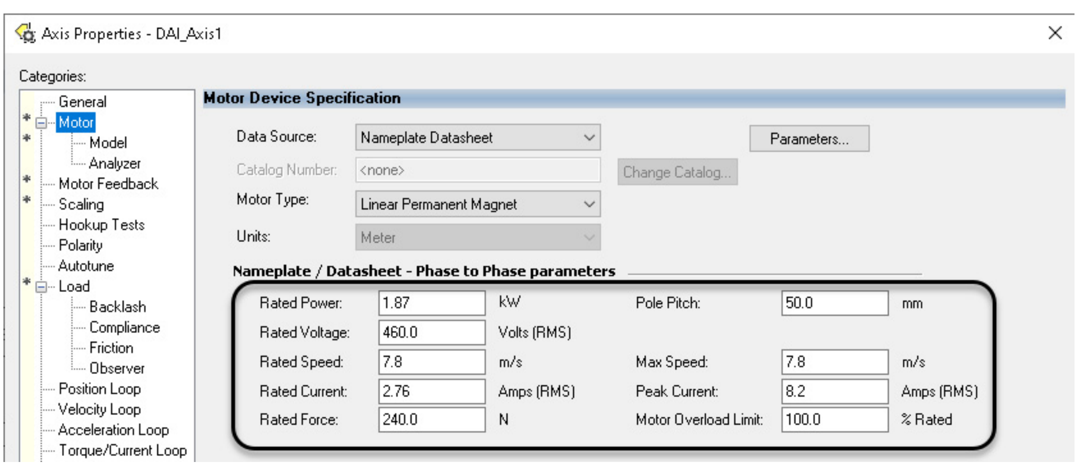



**Figure 12 - Linear Permanent-magnet Motor Type Example**



### Table 3 - Motor Type Attribute Definitions

| Datasheet Attribute | Definition | Rotary Induction | Rotary PM | Linear PM |
|---|---|---|---|---|
| Rated Power | Sometimes known as Motor Rated Output Power, rated power (kW) is a floating point number that is a representation of the motor power output under full load conditions of rated current, speed, and voltage.<br>• Typical 460V AC induction motors are rated in HP (nameplate datasheet requires entry in kW). The conversion is: 1 Hp = 747 Watts or 0.747 kW.<br>• Typical 400V AC induction motors are rated in kW.<br>• Typical permanent magnet motors are rated in kW. | X | X | X |
| Rated Voltage | Sometimes known as Motor Rated Voltage, rated voltage (volts AC, rms) is a floating point number that represents the phase-to-phase voltage applied to the motor that is required to reach rated speed at full load.<br>**IMPORTANT** Many motor vendors provide general AC voltage class ratings, such as 400V-class. A motor can be marketed as a 460V AC motor but the phase-to-phase voltage is 405V AC. This lower voltage changes the volts per Hertz curve and affects proper motor control. Verify the correct phase-to-phase voltage from the motor performance sheet or equivalent circuit diagram. If the phase-to-phase voltage is lower than the marketed motor voltage, use the phase-to-phase value as the rated voltage. | X | X | X |
| Rated Current | Sometimes known as Motor Rated Continuous Current or Stall Current, rated current (Amps, rms) is a floating point number that represents the current applied to the motor under full-load conditions at motor zero speed and rated voltage (any positive number).<br>• Rated current for an induction motor is calculated as SQRT (flux current$^2$ + torque current$^2$). Flux current is referred to as the motor no load current that is required to create magnetism in the motor. Torque current is described as the useful current when the motor is producing torque. It is current that is in phase with the motor output voltage.<br>• Rated current for a permanent magnet motor is purely torque current because the motor magnet already generates the flux. It is current that is in phase with the motor output voltage.<br>**IMPORTANT** Many motor manufacturers may not use Amps rms to indicate Motor Rated Continuous Current. Rather, 0-peak current values are used. If a 0-peak current value is used, you must convert this value to Amps rms. For example, Amps 0-peak = 1.414 Amps rms. | X | X | X |
| Rated Speed | Sometimes known as Motor Rotary Rated Speed, rated speed (rpm) or Linear Motor Rated Speed (m/s) is a floating point number that is synonymous with rated base speed.<br>• When using an induction motor, the Rated Speed is the actual speed at rated load and rated fundamental frequency. This speed is lower than the synchronous speed because of slip.<br>• When using permanent magnet motors, there is no slip so the rotor and stator are synchronously rotating. In the Logix Designer application, rated speed is the same value as maximum speed. It is possible to overspeed a permanent magnet motor, but that is out of scope for this publication.<br>See Rated Speed Calculations on page 14 for how to calculate slip and interpret your torque/speed curve. | X | X | X |
| Rated Torque | Rated torque is usually found on a permanent magnet motor. Sometimes known as Motor Rated Torque or Stall Torque, rated torque (N•m) is a floating point number that specifies the nameplate continuous torque rating of a rotary permanent magnet motor. | — | X | — |
| Rated Force | Usually found on a permanent magnet motor, the Motor Rated Force, or rated force (N), is a floating point number that specifies the nameplate continuous force rating of a linear permanent magnet motor. | — | — | X |
| Pole Count | Pole Count is sometimes known as Rotary Motor Poles. For one motor rotation, this is the integer number of poles. Poles are always an even number as poles always exist in pairs. Poles affect the motor rated speed.<br>**IMPORTANT** Motor manufacturers sometimes refer to Pole Pairs. For example, a 21 pole-pair motor. 21 pole pairs equal a 42 pole count, which is what you enter in the Axis Properties > Motor nameplate datasheet. | X | X | — |
| Pole Pitch | Sometimes known as Linear Motor Pole Pitch, pole pitch (mm) is a floating point number that specifies the Electrical Cycle Length of a linear motor. This is measured from the north magnet to the next north magnet in a linear motor. In Kinetix drives, this value must be an integer, fractional pole pitches are not supported. | — | — | X |
| Rated Frequency | Usually found on a rotary induction motor, Motor Rated Frequency (Hz) is a floating point number that represents the motor rated frequency at synchronous speed. | X | — | — |

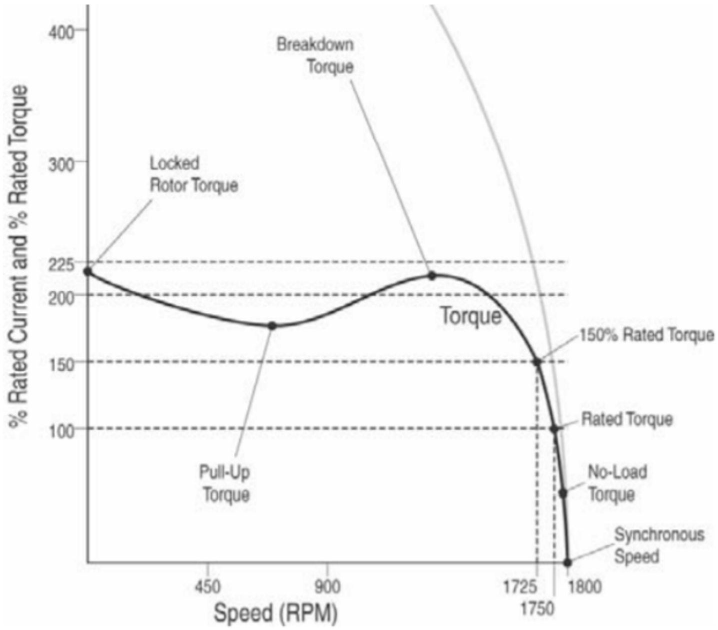
### Table 3 - Motor Type Attribute Definitions (Continued)

| Datasheet Attribute | Definition | Rotary Induction | Rotary PM | Linear PM |
|---|---|---|---|---|
| Maximum Speed (using Linear Motors) | Sometimes known as Linear Motor Max Speed, max speed (m/s) is a floating point number that represents speed as determined by the limitations of the motor, limitations of the drive power structure, or by limitations of the mechanical system, whichever is less. Specifically, this value can represent the maximum safe operating-speed, maximum continuous no-load motor speed, maximum encoder speed, maximum continuous motor-bearing speed, or maximum motor speed based on the drive power structure voltage limit. This value can be used by the drive to determine the Linear Motor Overspeed Factory Limit. | — | — | X |
| Maximum Speed (using Rotary Motors) | Sometimes known as Rotary Motor Max Speed, maximum (max) speed (rpm) is a floating point number that represents speed as determined by the limitations of the motor, limitations of the drive power structure, or by limitations of the mechanical system, whichever is less. Specifically, this value can represent the maximum safe operating-speed, maximum continuous no-load motor speed, maximum encoder speed, maximum continuous motor-bearing speed, or maximum motor speed based on the drive power structure voltage limit. This value can be used by the drive to determine the Rotary Motor Overspeed Factory Limit.<br>• When determining the speed to use as the maximum speed for your system, one factor is the peak torque requirements of the application. Going above rated frequency with an induction motor is referred to as operating the AC induction motor above base speed. This is normally referred to as the reduced-flux current region. With lower flux, the motor can't generate as much torque. The motor equivalent diagram must be reviewed to determine if the motor torque at the higher speed meets the application performance expectations.<br>• Operation of the motor above base speed is not achieved by increasing the motor output voltage. Rather, speeds higher than base speed are achieved by increasing the Hz, and operating at a different point on the V/Hz curve. Maximum peak torque is the peak torque provided when operating the motor at rated voltage and at a speed less than or equal to the base speed. With voltage held constant at the rated voltage, you can calculate the approximate torque at a speed above the base speed as follows. A sample curve showing the relation between torque and speed is provided in Calculate Maximum Speed and Peak Torque at Speeds Above Base Speed on page 14.<br><br>N = the motor speed as a multiple of the base speed<br>Peak torque measured in units of maximum peak torque = $1/N^2$<br><br>Example: Calculate the peak torque at 90 Hz when 60 Hz is the base speed.<br>N = 90 Hz/60 Hz = 1.5<br>Peak torque measured in units of maximum peak torque = $1/1.5^2$ = 0.44 maximum peak torque<br>• See Rated Speed Calculations on page 14 for how to calculate slip and interpret your induction motor torque/speed curve. The motor equivalent circuit diagram can also provide needed information. | X | X | — |
| Peak Current | Sometimes known as Motor Rated Peak Current, the peak current (A rms) rating of the motor is a floating point number that is often determined by the thermal constraints of the stator winding. This relates to the last entry for Motor Overload Limit when using the generic $I^2T$ thermal model. See Motor Overload Limit Calculation on page 15 for induction motor thermal modeling examples. | X | X | X |
| Motor Overload Limit | Motor Overload Limit is applicable to all motor types. If the drive applies an $I^2T$ motor overload protection method, then exceeding the specified Motor Overload Limit results in an overload condition and activates $I^2T$ overload protection. While the motor is overloaded, the tag AxisX.Motor Capacity attribute increases to indicate how much of the motor's available $I^2T$ overload capacity has been used. When Motor Capacity reaches 100%, the drive can optionally trigger a Motor Overload Action. When employing an overload protection method based on a motor thermal model, the Motor Capacity attribute value represents how much of the motor's rated thermal capacity, associated with the motor thermal model, has been used. Once the Motor Capacity value exceeds the Motor Overload Limit, the drive can optionally trigger a predetermined Motor Overload Action. The Motor Overload Limit can also be used by the drive to determine the absolute thermal capacity limit of the motor, for example, the Motor Thermal Overload Factory Limit that if exceeded, generates a Motor Thermal Overload FL exception.<br>• Normally an induction motor has a Service Factor that is defined in the industry as a multiplier, which when applied to the rated power or current of the motor, indicates the maximum power or current that the motor can carry without entering an overload condition.<br>See Motor Overload Limit Calculation on page 15 for induction motor thermal modeling examples. | X | X | X |

## Rated Speed Calculations

In this typical rotary induction (squirrel cage) motor example, the speed at rated torque value is less than the synchronous speed due to slip. Therefore, the rated speed that you enter is not the synchronous speed, but rather the asynchronous speed (which is the synchronous speed including the slip speed).

**Figure 13 - Typical Squirrel Cage AC Asynchronous Motor Base Torque Versus Speed Performance Curve**




In the torque/speed curve in Figure 13, 1750 rpm is the motor rated speed that corresponds to 100% rated torque. This is called the asynchronous speed in rpm. Therefore (from the torque/speed curve), slip is 50 rpm.

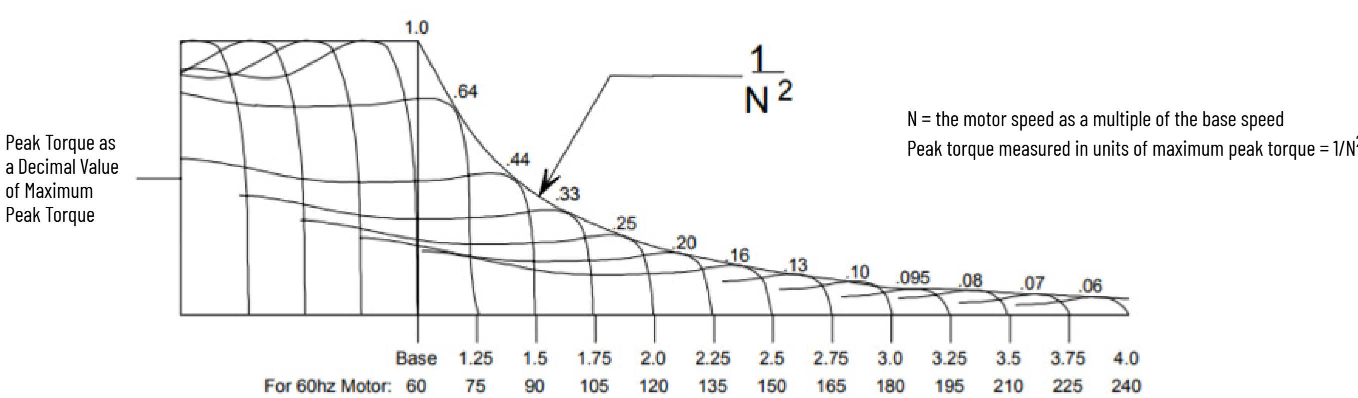
In the nameplate datasheet example on page 9, the Rated Speed was specified in the F.L. RPM field as 1800 rpm. Inserting values for all the variables results in the following equation and result:

$$\text{Rated Speed (at rated torque)} = \left(\frac{120 \cdot \text{Frequency}}{\text{Motor Poles}}\right) - \text{Slip Speed} \quad \text{OR} \quad 1780 \text{ rpm (asynchronous speed)} = 120 \cdot \left(\frac{60}{4}\right) - 20 \text{ rpm (slip speed)}$$

## Calculate Maximum Speed and Peak Torque at Speeds Above Base Speed

You can use this calculation to determine the maximum speed at which your system can operate while still meeting your peak torque requirements. See Maximum Speed (using Rotary Motors) on page 13 for more details about this calculation.

**Figure 14 - Sample Asynchronous Motor Torque Performance Above Base Speed**




| | |
|---|---|
| **IMPORTANT** | Contact the motor vendor for the motor-equivalent circuit diagram and performance curves to know what the expected motor torque is above base speed. |

## Motor Overload Limit Calculation

There are two types of Kinetix 5300, 5500, and 5700 induction motor thermal modeling methods: Generic I2T, and Thermally Characterized Motor Model.

## Generic I2T

Generic I2T is used more commonly and is the standard for Kinetix and PowerFlex® drive motor control. The purpose of this algorithm is to protect the motor by limiting the amount of time the motor is operating with excessive levels of current.

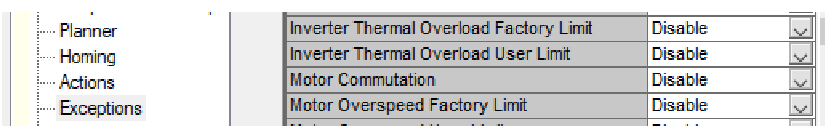
On the 7.5 Hp (5.6 kW) motor nameplate datasheet on page 10, S.F (motor service factor) is 1.0. In this case, the motor manufacturer wants the motor to enter a motor overload evaluation when the current is 10.71 A rms. Therefore, the motor overload limit value is entered as 100%. When the motor is used at 10.71 A, the I2T model begins to increase motor capacity (logarithmically) from its present value until it reaches 100% where the motor overload exception action is executed.

If the same motor had an S.F of 1.1, then the motor overload limit is entered as 110%. When the motor is used at 10.71 x 1.1 or 11.78 A, the I2T model begins to increase motor capacity (logarithmically) from its present value until it reaches 100% where the motor overload exception action is executed.

An induction motor can also have limits when running at lower speeds and convection cooling is not enough to cool the motor properly. The Kinetix 5300, 5500, and 5700 drive Generic I2T model derates the motor rated current (for thermal protection only) when operating at low speeds. The derating factor is 30% at 0 Hz and 0% at 20 Hz, with linear interpolation in between. Operating at output frequencies less than 20 Hz causes Motor Capacity to increase more quickly.

The default MotorOverloadLimit (Axis Properties > Parameter List) values for this thermal model are both 100%. The User and Factory MotorThermalOverload attributes are set as Disable by default.

**Figure 15 - Motor Thermal Overload Limits Disabled by Default**




## Thermally Characterized Motor Model

To use the Thermally Characterized Motor Model, you must acquire the MotorWindingToAmbientCapacitance and MotorWindingToAmbientResistance values in one of the following ways:

- The motor vendor supplies the J (Joules), °C (degrees Celsius), and W (Watts) values used to calculate the capacitance and resistance values.
- The motor vendor supplies the motor thermal constant in minutes or seconds, and the thermal resistance (the MotorWindingToAmbientResistance value). From these values, you can calculate the MotorWindingToAmbientCapacitance using the following formula:

$$\frac{\text{Time Constant in seconds}}{\text{MotorWindingToAmbientResistance}} = \text{MotorWindingToAmbientCapacitance}$$

If you cannot acquire the values in either of the preceding ways, use the Generic I2T model.

The Thermally Characterized Motor model uses the MotorWindingToAmbientResistance and MotorWindingToAmbientCapacitance attribute values as follows. When both values are nonzero, the motor is considered thermally characterized and an alternate motor thermal model is run. The purpose of this algorithm is to protect the motor by limiting the amount of time the motor is operating with excessive levels of current. The Thermally Characterized Motor model uses the first order time constant that is determined from the MotorWindingToAmbientResistance and MotorWindingToAmbientCapacitance values to estimate the motor thermal capacity based on the motor output current.

The example in Figure 16 applies to rotary inductions motors.

**Figure 16 - Motor > Motion Axis Parameters (default data)**

| | | | |
|---|---|---|---|
| | MotorWindingToAmbientCapacitance | 0.0 | J/°C |
| | MotorWindingToAmbientResistance | 0.0 | °C/W |

The example in Figure 17 applies to rotary permanent-magnet motors.

**Figure 17 - Motor > Motion Axis Parameters (MPL-B320P data)**

| | | | |
|---|---|---|---|
| | MotorWindingToAmbientCapacitance | 1227.0 | J/°C |
| | MotorWindingToAmbientResistance | 0.88 | °C/W |

The example in Figure 18 applies to linear permanent-magnet motors.

**Figure 18 - Motor > Motion Axis Parameters (LDC-C100300 data)**

| | | | |
|---|---|---|---|
| | MotorWindingToAmbientCapacitance | 8182.0 | J/°C |
| | MotorWindingToAmbientResistance | 0.33 | °C/W |

The low-speed derating is not used as the Thermally Characterized Motor model is constantly monitoring and evaluating drive-to-motor current, based on the motor winding to ambient capacitance and resistance.

**IMPORTANT** The Thermally Characterized Motor model does not derate the motor-rated current when operating at low speeds. Operating at low output frequencies does not cause the MotorCapacity behavior to change.

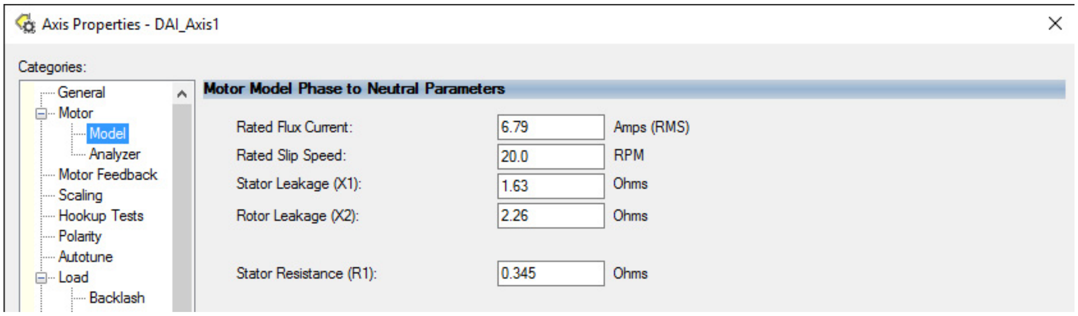
The MotorOverloadAction still executes when the motor capacity is at 100%. The Thermally Characterized Motor model supports setting the MotorOverloadAction attribute as Current Foldback. Selecting the Current Foldback action results in a reduction in the current reference via the MotorThermalCurrentLimit attribute value that is reduced in proportion to the percentage difference between the MotorCapacity and the MotorOverloadLimit values.

Unlike the Generic I2T model, when the Thermally Characterized Motor model is active, the MotorCapacity attribute is nonzero if the motor output current is nonzero. The default MotorThermalOverloadFactoryLimit and MotorThermalOverloadUserLimit values for this thermal model are both 110%.

## Motor > Model Category

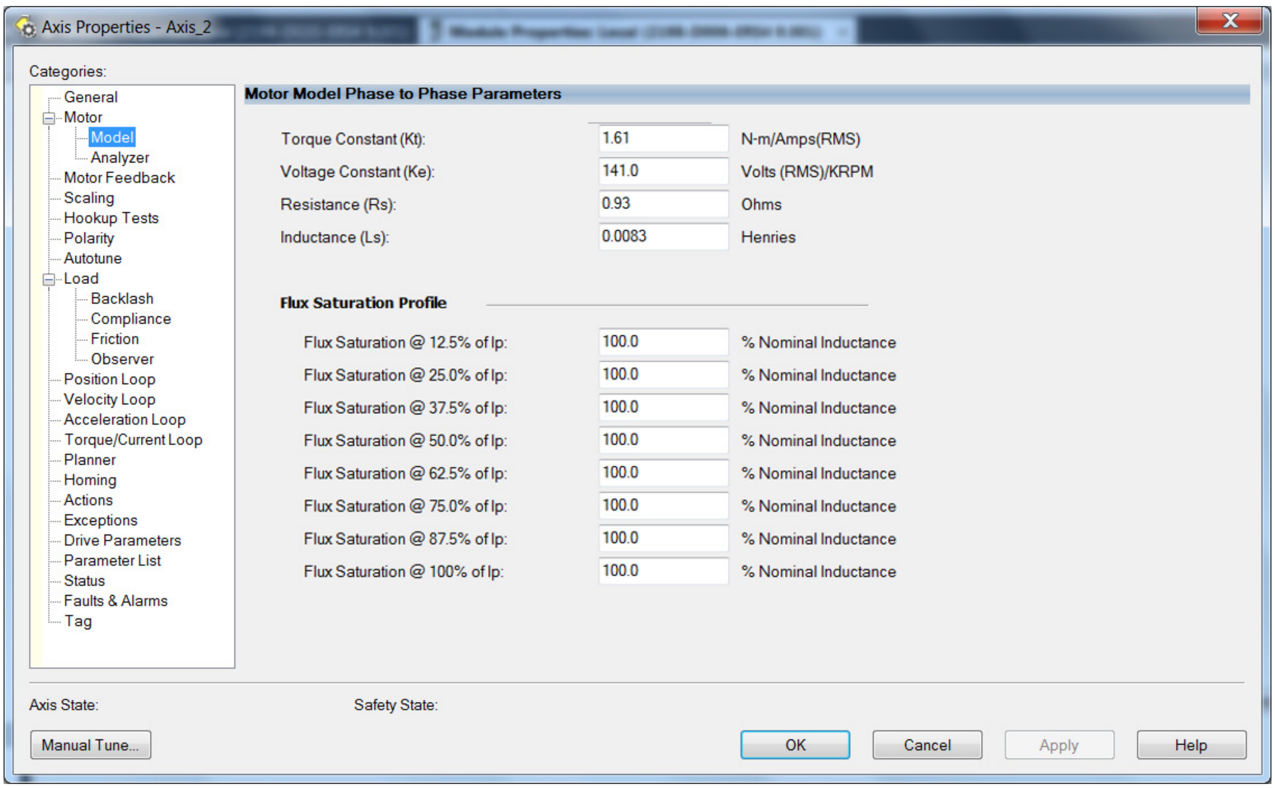
Figure 19 shows the motor model phase to neutral parameters.

**Figure 19 - Rotary Induction Motor Model Example**

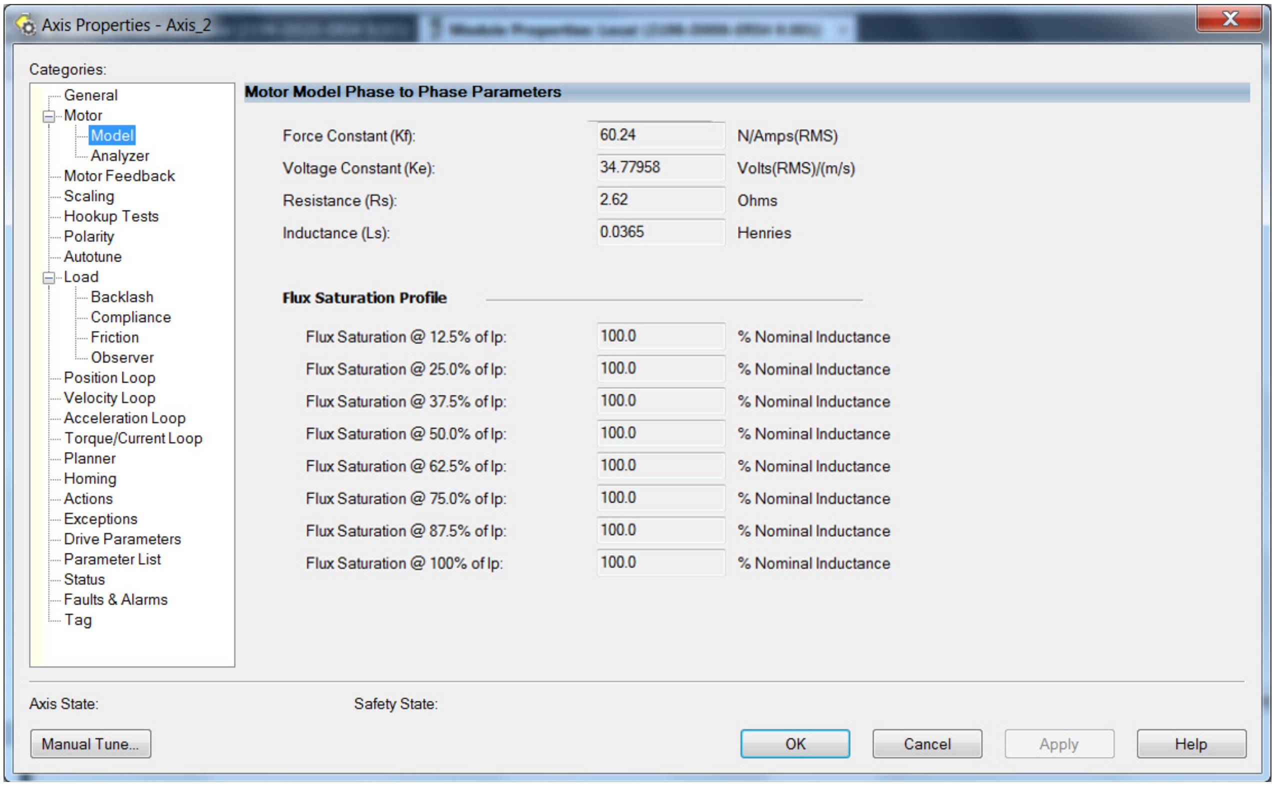



The examples in Figure 20 and Figure 21 on page 18 show the motor model phase-to-phase parameters.

**Figure 20 - Rotary Permanent-magnet Motor Model Example**

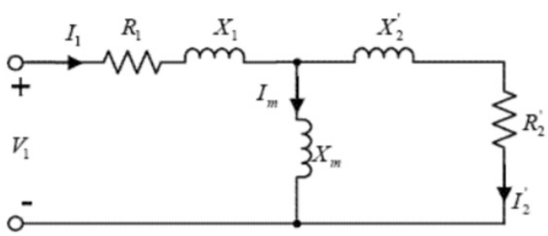


### Figure 21 - Linear Permanent-magnet Motor Model Example




An induction motor has phase-to-neutral characteristics that are entered in the Motor > Model category and used in the Kinetix 5300, 5500, and 5700 drive control to generate output voltage, frequency and current.

### Figure 22 - IEEE Induction Motor Per Phase Mode




### Table 4 - Rotary Induction Motor Model Attribute Definitions

| Datasheet Attribute | Definitions |
|---|---|
| Rated Flux Current | Sometimes known as Induction Motor Flux Current, rated flux current (Amps rms) is an ID Current Reference that is required to generate full motor flux. This value is closely approximated by the No Load Motor Rated Current that is commonly found in induction motor datasheets.<br>• If the flux is too low, the motor cannot be magnetized properly, so expect improper output torque from the motor. Possible observation is a motor overload fault.<br>• If the flux is too high, the drive has less ability to provide torque current. Possible observation is an inverter overcurrent fault.<br>See Motor Flux Current Versus Motor Power Guidelines on page 19 for approximate values. |
| Rated Slip Speed | Sometimes known as Induction Motor Slip Speed, rated slip speed (rpm) is a floating point number that represents the amount of slip at motor rated current (full load) and motor rated frequency. |
| Stator Leakage (X1) | Sometimes known as Induction Motor Stator Leakage Reactance, stator leakage X1 (ohms) is a floating point number that specifies the Y circuit, phase-neutral, leakage reactance of the stator winding, at rated frequency, and shown as X1 in the IEEE motor model. |
| Rotor Leakage (X2) | Sometimes known as Induction Motor Rotor Leakage Reactance, rotor leakage X2 is a floating point number that specifies the Y circuit, phase-neutral, equivalent stator-referenced leakage inductance of the rotor winding, at rated frequency, and shown as X2 in the IEEE motor model.<br>**IMPORTANT** In a motor performance datasheet, the X1 and X2 values vary, even if only slightly. This lets the motor model use X1 and X2 as similar values for modeling and calculation purposes. |
| Stator Resistance (R1) | Sometimes known as Induction Motor Stator Resistance, stator resistance R1 is a floating point number that specifies the Y circuit, phase-neutral, winding resistance of the stator, and shown as R1 in the IEEE motor model. Generally, the R1 resistance is smaller than the reactance X1 and X2 values. For small motors, with small cable windings, the resistance values are larger. For large motors, with large cable windings, the values are smaller. |

When you are using a rotary induction motor and the Flux Current value is not given by the motor manufacturer, follow the guidelines in Table 5.

**Table 5 - Motor Flux Current Versus Motor Power Guidelines**

| Motor Power | Flux Current (Approx) |
|---|---|
| Less than 5 Hp | 50…75% of motor FLA |
| Greater than 5 Hp | 33…50% of motor FLA |

**Table 6 - Permanent-magnet Motor Model Attribute Definitions**

| Datasheet Attribute | Definition | Rotary PM | Linear PM |
|---|---|---|---|
| Torque Constant | The Torque Constant (Kt) attribute is a floating point number that specifies the shaft output torque/Amps of rotary permanent-magnet motors measured in N•m/Amps, rms.<br>**IMPORTANT** Make sure that your value for torque constant is in Amps, rms. Many motor vendors use 0-peak values for both voltage and torque constant values for consistency. $Kt_{rms}$ = 1.414 x Kt 0-peak. | X | – |
| Force Constant | The Force Constant (Kf) attribute is a floating point number that specifies the force/Amps of linear permanent-magnet motors measured in N/Amps, rms. | – | X |
| Voltage Constant | Rotary permanent-magnet motor: Voltage Constant (Ke) sometimes known as PM Rotary Motor Voltage Constant is a floating point number that specifies the voltage (or back-EMF) measured in phase-to-phase rms Volts per KRPM. If the optional PM Motor Torque Constant (Kt) is not explicitly supported in the implementation, the value can be computed from the PM Motor Rotary Voltage Constant (Ke) according to this equation: Kt (N•m/A) = 0.01654 x Ke (V/Krpm). | X | – |
| | Linear permanent-magnet motor: Voltage Constant (Ke) sometimes known as PM Linear Motor Voltage Constant is a floating point number that specifies the voltage (or back-EMF) measured in phase-to-phase rms Volts per meter/second. If the optional PM Motor Force Constant (Kf) is not explicitly supported in the implementation, the value can be computed from the PM Motor Linear Voltage Constant (Ke) according to this equation: Kf (N/A) = 1.732 x Ke (V/(m/s)).<br>**IMPORTANT** Make sure that your value for torque constant is in Amps, rms. Many motor vendors use 0-peak values for both voltage and torque constant values for consistency. $Ke_{rms}$ x 1.414 = Ke 0-peak. | – | X |
| Resistance | Resistance (Rs), sometimes known as PM Motor Resistance is a floating point number that specifies the phase-to-phase resistance of a permanent magnet motor in Ohms. | X | X |
| Inductance | Inductance (LS) sometimes known as PM Motor Inductance is a floating point number that specifies the phase-to-phase inductance of a permanent magnet motor in Henries. | X | X |
| Flux Saturation | Flux Saturation sometimes known as PM Motor Flux Saturation is an array of floating point numbers that specify the amount of flux saturation in the motor as a function of current. The units for the nominal inductance values are percent, such that a value of 100% means no saturation, and 90% means that the inductance is 90% of its value at zero current. This array of values is arranged as a profile in the Axis Properties > Motor > Model selection in the Studio 5000 Logix Designer application.<br>• The first array entry specifies the flux saturation value at 12.5% of the Peak Current Rating (Ip).<br>• The second entry specifies the value at 25%, and so on…<br>• The last entry specifies the value at 100% of the Peak Current Rating.<br>• At zero current, the motor is assumed to have no saturation. This means an implied value of 100%.<br>• If none of these values are known, enter 100% for all of them. An example Flux Saturation profile is shown in Figure 20 on page 17. | X | X |

# Motor > Analyzer Category

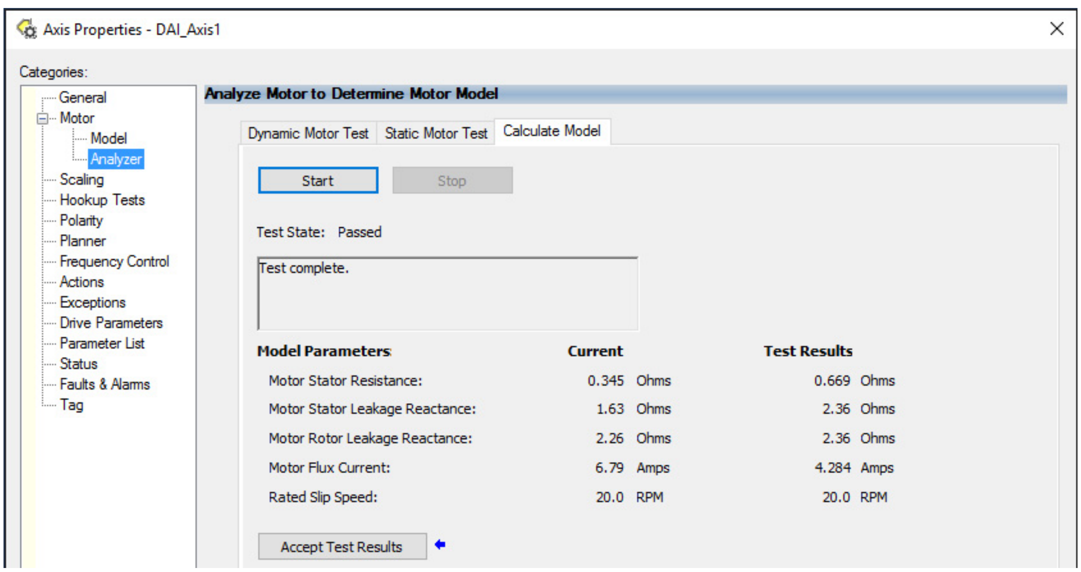
When using the Nameplate Datasheet as the data source, you the user must enter all motor data. When Nameplate Datasheet is used as the data source, a catalog number is not available unless a custom motor file (CMF) is obtained for any induction, rotary, or linear SPM motors. If the motor model data is not readily available in a datasheet, the motor must be characterized by the Kinetix 5300, 5500, or 5700 drive. This characterization attempts to generate an accurate representation of motor data that is already provided with a catalog-number-based Kinetix servo motor. There are three tests that can be run based on the axis configuration.

### Table 7 - Motor Tests and Autotune Matrix

| Control Mode | Frequency Control Method | Calculate Model (1) | Static Motor Test (1) | Dynamic Motor Test (1) | Autotune |
|---|---|---|---|---|---|
| Induction motor - Frequency control | Basic volts/hertz | Not required | Not required | Not required | Not required |
| | Basic volts/hertz for Fan/Pump | Not required | Not required | Not required | Not required |
| | Sensorless vector | Required (2) | Preferred | Not required | Not required |
| Induction motor - Closed-loop control | | Required (2) | Acceptable in some situations (3) | Preferred (3) | Required (2) (4) |
| Rotary Surface Permanent Magnet (5) | | – | – | – | Required (6) |
| Linear Surface Permanent Magnet (5) | | – | – | – | Required (6) |

(1) You can find these tests, test data, and test results at Axis Properties > Motor > Analyzer. See Figure 23.
(2) Not required for the Logix Designer application, version 29.00 and later.
(3) For Induction motor - Closed loop control, the Dynamic Motor Test provides the best results and is the preferred test. In some situations, when the load cannot be de-coupled from the motor, you can use the Static Motor Test in its place.
(4) When using Induction motor - Closed loop control, the motor inertia value must be nonzero before running a Dynamic Motor Test. The motor inertia value is estimated automatically based on the motor nameplate data in the Logix Designer application, version 29.00 and later. For previous versions, an Autotune must be run or the motor inertia value must be entered directly.
(5) Permanent magnet motors do not require Calculate Model, Static Motor Test, or Dynamic Motor Test.
(6) When using closed-loop control, additional tuning may be required depending on your mechanical system and application requirements. See the Motion System Tuning Application Technique, publication MOTION-AT005, for details about using different tuning techniques.

### Figure 23 - Axis Properties > Motor > Analyzer Tests




# Calculate Model

When a Calculate Model test is run, the drive uses motor nameplate data to estimate the motor's Rated Flux Current, Stator Resistance (Rs), Stator Leakage Reactance (X1), and Rotor Leakage Reactance (X2). The drive also calculates the rated slip speed based on the rated speed and rated frequency.

## Static Motor Test

Use the Static test if the motor shaft cannot rotate or if it is already coupled to the load. Only tests that do not create motor movement are run. During this test, the Stator Resistance (Rs), Stator Leakage Reactance (X1), and Rotor Leakage Reactance (X2) values are measured during a series of static tests. The Rated Flux Current is estimated, since accurate measurement of this value requires motor movement. The drive also calculates the rated slip speed based on rated speed and rated frequency.

The Static test requires that you enter initial estimates for Rated Flux Current, Stator Resistance (Rs), Stator Leakage Reactance (X1), and Rotor Leakage Reactance (X2) into the Motor Model fields.

- For the Logix Designer application, version 29.00 or later, initial estimates are populated by the controller.
- For the Logix Designer application, version 28.00 or earlier, initial estimates can be populated by running and accepting the results of a Calculate test, or by entering the values directly into the Logix Designer application.

## Dynamic Motor Test

Dynamic tests are run with the motor disconnected from the load because the motor shaft turns and there are no travel limits. This is often the most accurate test method. During this test, the Stator Resistance (Rs), Stator Leakage Reactance (X1), and Rotor Leakage Reactance (X2) values are measured in a series of static tests. The Rated Flux Current is measured during a rotational test, in which the drive commands 75% of the motor rated speed. The rated slip speed is measured during a second rotational test, in which the drive commands a speed (default of 100% of the motor rated speed) and sets a torque limit (default of 50% of the motor rated torque). This second test quickly accelerates the motor to rated speed and then decelerates back to zero speed.

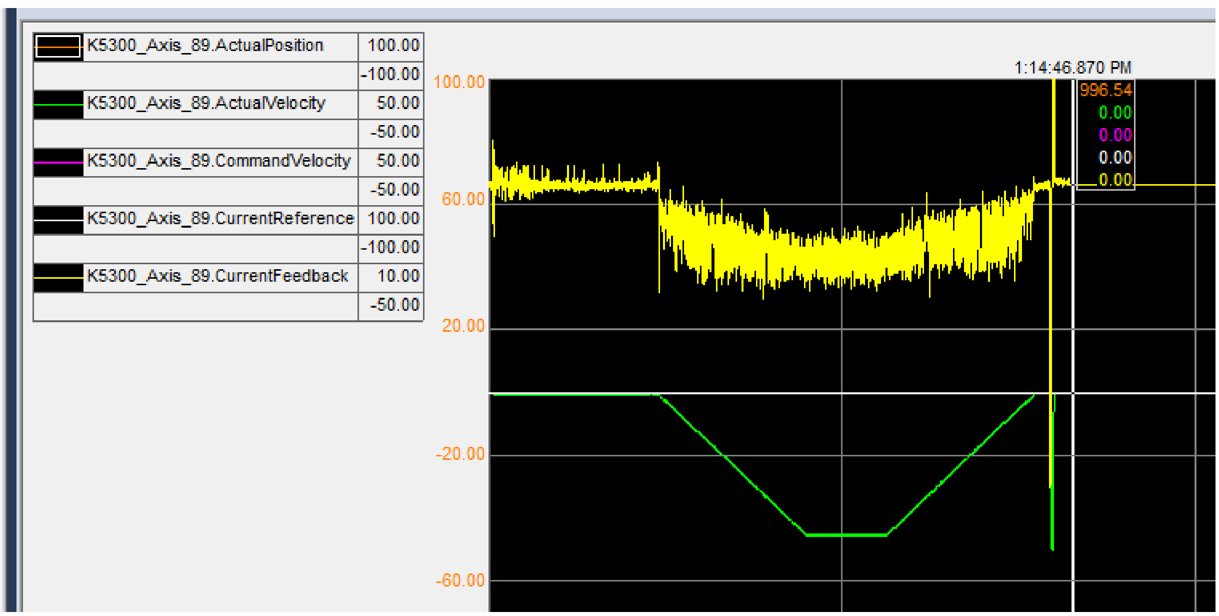
| | |
|---|---|
| **IMPORTANT** | The Dynamic Motor Test does not support travel limits. |

The Dynamic test also requires that you enter initial estimates for Rated Flux Current, Stator Resistance (Rs), Stator Leakage Reactance (X1), and Rotor Leakage Reactance (X2) into the Motor Model fields.

- For the Logix Designer application, version 29.00 or later, initial estimates are automatically populated by the controller.
- For the Logix Designer application, version 28.00 or earlier, initial estimates can be populated by running and accepting the results of a Calculate test, or by entering the values directly into the Logix Designer application.

The Dynamic test uses the Ramp Acceleration and Ramp Deceleration attributes to set the rotational test ramp-up and ramp-down times. If the resulting acceleration/deceleration times are less than 10 seconds, 10 seconds is used. If these attributes are not supported, 10 seconds is used. When using a rotary induction motor, after the Acceleration/Deceleration profile is complete, a short high Acceleration/Deceleration command is used to provide a closer estimate for slip speed.

**Figure 24 - Example of the Dynamic Motor Test Profile Moving a Rotary Induction Motor**



When configured for closed-loop control, the Dynamic test requires that an accurate system inertia is set in the Logix Designer application.

- For the Logix Designer application, version 29.00 or later, a default value is automatically populated by the controller.
- For the Logix Designer application, version 28.00 or earlier, this value can be populated by running and accepting the results of an Autotune test, or by entering the motor inertia value directly into the Logix Designer application.

Executing the Dynamic test multiple times can help you be sure that the resulting motor characteristics are similar across multiple executions of the test. This provides confidence that the motor model values are correct.

## Configure Motor Feedback

When the axis uses closed loop control and is configured for position, velocity, or torque loop control, motor feedback must be configured in the Logix Designer application. This section only shows Kinetix 5300 and Kinetix 5700 examples.

**IMPORTANT** Rotary induction motors with feedback that are in Frequency Control mode do not use motor-mounted feedback devices.

Table 8 shows valid feedback types that can be associated with different Axis Configurations (Drive Module Add-On Profile > Motion > Associated Axes). This table assumes the Kinetix 5300 or 5700 drives are updated to firmware revision 13 or later.

**Table 8 - Valid Feedback Assignments**

| Feedback Type | | Axis Properties > Motor Type | |
|---|---|---|---|
| | | **Permanent Magnet Motors** | **Induction Motors** |
| Hiperface DSL | High-resolution single-turn and multi-turn, absolute | Axis Properties > Feedback Configuration: can be configured as Motor Feedback, Load (and Dual) Feedback [1] | |
| Hiperface | | | |
| Digital AqB | Incremental | | |
| Digital AqB with UVW | | | |
| Sine/Cosine | | | |
| Sine/Cosine with UVW | | | |
| EnDat Sine/Cosine | High-resolution single-turn and multi-turn, absolute | | |
| EnDat Digital | | | |

(1) Kinetix 5300 drives support Load (and Dual) Feedback as Digital AqB only.

**Table 9 - Universal Feedback General Specifications (Kinetix 5700) [1]**

| Attribute | Axis Configuration: Position, Velocity, Torque Loop [2] | Axis Configuration: Feedback Only [3] |
|---|---|---|
| Feedback Device Supported - Universal Feedback Port (UFB) | Hiperface [4] | Hiperface [4] |
| | Generic TTL Incremental [5] | Generic TTL Incremental [5] |
| | Generic Sine/Cosine Incremental [5] | Generic Sine/Cosine Incremental [5] |
| | EnDat Sin/Cos [6] | EnDat Sin/Cos [6] |
| | EnDat Digital [7] | EnDat Digital [7] |
| Power supply voltage (MTR_EPWR5V) | 5.27…5.50V [8] [9] | |
| Power supply current (MTR_EPWR5V) | 300 mA, max | |
| Power supply voltage (MTR_EPWR9V) | 8.30…9.90V [8] [9] | |
| Power supply current (MTR_EPWR9V) | 150 mA, max | |
| Thermostat | Single-ended, under 500 Ohms = no fault | |
| | Single-ended, over 10,000 Ohms = fault | |

(1) Kinetix 5700 DSL Feedback Port is only compatible with Kinetix motor feedback types.
(2) Kinetix 5700 firmware revision 13 or later allows these device types (Feedback Configurations) to be set as Motor or Load Feedback.
(3) Kinetix 5700 firmware revision 13 or later allows these device types (Feedback Configurations) to be Master Feedback.
(4) Not all Stegmann devices are supported. Must be a SICK Stegmann device, see Table 12 on page 23 for compatible devices.
(5) Kinetix 5700 firmware 13 or later allows these feedback devices to be used with or without HALL effect sensors (UVW).
(6) EnDat sine/cosine encoders support only Kinetix RDB motors.
(7) EnDat digital encoders support VPC-B*xxxxx*-Y motors and applicable third-party motors.
(8) For 2198-D*xxx*-ERS*x* (dual-axis) drives, these motor feedback voltage and current ratings are per axis.
(9) Be sure of the power supply your feedback device uses and do not attempt to use both power supplies. Only one power supply (5V or 9V) must be used.

### Table 10 - Drive Feedback General Specifications (Kinetix 5300) (1)

| Attribute | Axis Configuration: Position, Velocity, Torque Loop | Axis Configuration: Feedback Only |
|---|---|---|
| Feedback Device Supported - Motor Feedback Port (MFB) (2) | Nikon (24-bit) serial (only used with Kinetix TLP motors) | Nikon (24-bit) serial (only used with Kinetix TLP motors) |
| | Tamagawa (17-bit) serial (only used with Kinetix TL/TLY motors) | Tamagawa (17-bit) serial (only used with Kinetix TL/TLY motors) |
| | Hiperface (3) | Hiperface (3) |
| | Generic TTL Incremental | Generic TTL Incremental |
| | Generic Sine/Cosine Incremental | Generic Sine/Cosine Incremental |
| Feedback Device Supported - Auxiliary Feedback Port (AUX) | - | Generic TTL Incremental (4) |
| Power supply voltage (MTR_EPWR5V) | 5.10…5.40V (5) | |
| Power supply current (MTR_EPWR5V) | 300 mA, max | |
| Power supply voltage (MTR_EPWR9V) | 8.10…9.90V (5) | |
| Power supply current (MTR_EPWR9V) | 150 mA, max | |
| Thermostat | Single-ended, under 500 Ohms = no fault | |
| | Single-ended, over 10,000 Ohms = fault | |

(1) Kinetix 5300 drives do not support Hiperface DSL.
(2) When using the MFB Port, the feedback device is configured as Motor Feedback.
(3) Not all Stegmann devices are supported. Must be a SICK Stegmann device, see Table 12 on page 23.
(4) When using the AUX Feedback Port, the feedback device is configured as Master or Load Feedback.
(5) Be sure of the power supply your feedback device uses and do not attempt to use both power supplies. Only one power supply (5V or 9V) must be used.

### Table 11 - Hiperface Specifications (Kinetix 5300/5700) (1)

| Specification | Value |
|---|---|
| Memory support | Not programmed, or programmed with Allen-Bradley motor data |
| Hiperface data communication | 9600 baud, 8 data bits, no parity |
| Sine/cosine interpolation | 4096 counts/sine period |
| Input frequency (AM/BM) | 250 kHz, max |
| Input voltage (AM/BM) | 0.6…1.2V, peak to peak, measured at the drive inputs |
| Line loss detection (AM/BM) | Average ($\sin^2 + \cos^2$) > constant |
| Noise filtering (AM and BM) | Two-stage coarse count pulse reject filter with rejected pulse tally |
| Incremental position verification | Position comparison between incremental accumulator and serial data performed every 50 ms or less |

(1) Kinetix 5500 can use TTK50, TTK70, or Kinetix motors with compatible feedback + 2198-H2DCK Series B feedback connector (Hiperface-to-DSL converter).

### Table 12 - Hiperface Compatibility (Kinetix 5300/5700) (1) (2) (3)

| Device Type | Value |
|---|---|
| SICK Stegmann (Optical; Single-turn) | SRS50, SRS60, SRS64, SFS60, SKS36 |
| SICK Stegmann (Optical; Multi-turn) | SRM50, SRM60, SRM64, SFM60, SKM36 |
| SICK Stegmann (Linear) | TTK50, TTK70 (4) |

(1) Kinetix 5500 drives support these encoders using the 2198-H2DCK converter, Series B or later).
(2) SICK Capacitive Encoder types are not supported, with the following exceptions: SES70 and SEM70 used with Kinetix 5300/5700 and firmware revision 13 or later.
(3) Use the Universal Feedback Port with the Kinetix 5700, or use 2198-H2DCK with the DSL Feedback Port.
(4) Supported using Kinetix 5500 firmware revision 7 or later and Kinetix 5300/5700 firmware revision 9 or later. See the Knowledgebase https://rockwellautomation.custhelp.com/app/answers/answer_view/a_id/1070751.

### Table 13 - Generic TTL Specifications (Kinetix 5300/5700)

| Attribute | Value |
|---|---|
| TTL incremental encoder supporting Quadrature interpolation | 5V, differential A quad B |
| Differential input voltage (MTR_AM, MTR_BM, and MTR_IM) | 4 counts / square wave period |
| DC current draw | 5V DC, differential line driver (DLD) output compatible |
| (MTR_AM, MTR_BM, and MTR_IM) | 30 mA, max |
| Input signal frequency (MTR_AM, MTR_BM, and MTR_IM) | 5.0 MHz, max |

### Table 13 - Generic TTL Specifications (Kinetix 5300/5700) (Continued)

| | |
|---|---|
| Edge separation (MTR_AM and MTR_BM) | 42 ns min, between any two edges |
| Commutation verification (1) | A commutation angle verification is performed at the first Hall signal transition. Additional verifications are performed periodically thereafter. |
| Hall Sensor Inputs (MTR_S1, MTR_S2, and MTR_S3) | Single-ended, TTL, open collector, or none |

(1) Commutation verifications can occur with or without HALL effect sensors (UVW).

### Table 14 - Generic Sine/Cosine Incremental Specifications (Kinetix 5300/5700) (1)

| Attribute | Value |
|---|---|
| Sine/Cosine interpolation | 2048 counts/sine wave period |
| Input frequency (MTR_SIN and MTR_COS) | 250 kHz, max |
| Differential input voltage (MTR_SIN and MTR_COS) | 0.6…1.2V, p-p |
| Commutation verification | Commutation angle verification per signal transition and periodically verifies thereafter |
| Hall Sensor Inputs (MTR_S1, MTR_S2, and MTR_S3) | Single-ended, TTL, open collector, or none |

(1) This feedback type can be used with or without HALL effects (UVW). See Table 16 for the supported commutation type.

### Table 15 - EnDat Sine/Cosine Interface Specifications (Kinetix 5700) (1)

| Attribute | Value |
|---|---|
| Protocol | EnDat Sine/Cosine |
| EnDat Sine/Cosine data communication | 2 Mbps, synchronous |
| Sine/Cosine interpolation | 2048 counts/sine wave period |
| Input frequency (MTR_SIN and MTR_COS) | 250 kHz, max |
| Differential input voltage (MTR_SIN and MTR_COS) | 0.6…1.2V, p-p |
| Incremental position verification | Position comparison between incremental accumulator and serial data performed every 50 ms or less. |

(1) Endat feedback is not used with the Kinetix 5300.

### Table 16 - Support Requirements for EnDat Encoders (Kinetix 5700) (1) (2)

| Requirement | EnDat Sine/Cosine | EnDat Digital (3) |
|---|---|---|
| Supported Models | LC 483<br>ECI 119 (4)<br>ECN 113<br>ECN 1313/EQN 1325<br>413/EQN 425 | LIC 4000<br>ECI 119 (4)<br>ROQ 437<br>ECN 1123/ EQN 1135 ECN 1325 / EQN 1337<br>ECI 1319/EQI 1331<br>ECN 125 |
| Position Initialization | Digital | |
| Position Tracking | Uses sine/cosine signals | Digital |
| Data Frequency | 100 kHz | 4.125 MHz |
| Sin/Cosine Frequency | 0…250 kHz | — |

(1) Kinetix 5700 drive firmware must be revision 5.0 or later.
(2) Endat feedback is not used with the Kinetix 5300.
(3) EnDat Digital data communication rate is 4 Mbps, synchronous.
(4) ECI 119 can be procured as either EnDat Sin/Cos or EnDat Digital.

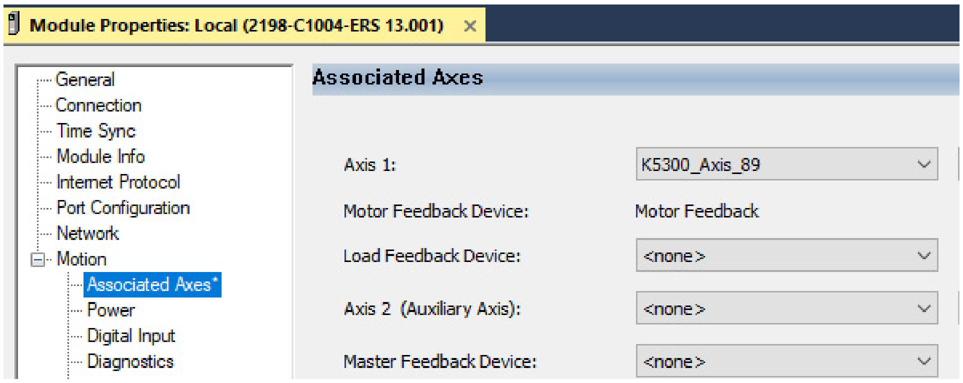
## Configure the Universal Feedback Port

Use the procedure for your drive:

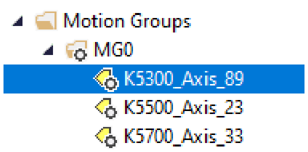
- Kinetix 5300 - Configure the Universal Feedback Port on page 25
- Kinetix 5700 - Configure the Universal Feedback Port on page 26

### *Kinetix 5300 - Configure the Universal Feedback Port*

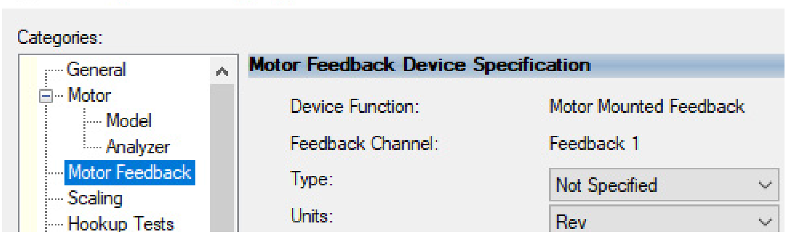
1. Right-click a Kinetix 5300 drive module in the Controller Organizer and choose Properties.
2. Navigate to Module Properties > Motion > Associated Axes.
3. Assign your Motion Axis (from the Motion Group) to Axis 1 by using the Axis 1 dropdown menu.




4. In the Motion Group, double-click the axis that was selected in step 3.



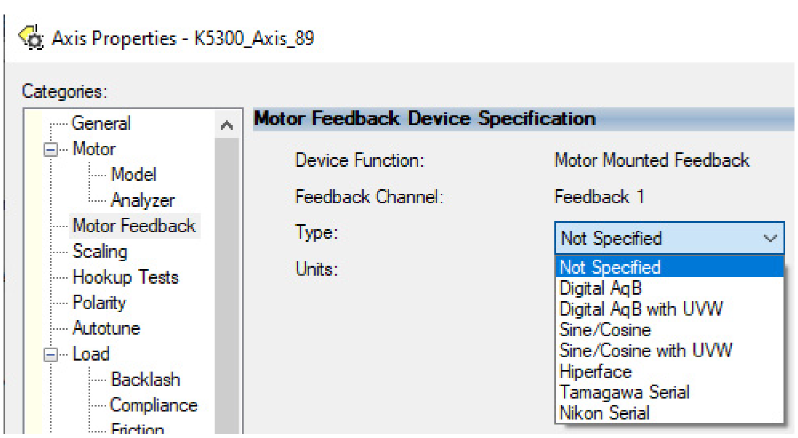

5. Navigate to Axis Properties > Motor Feedback.




6. Choose your feedback type from the Type dropdown menu.

| | |
|---|---|
| **IMPORTANT** | Not all of the feedback types that are listed in the Type menu are available for all the control modes. See Table 2 on page 5 for drive, motor, and feedback compatibility. This compatibility will be validated once you download your project into the controller. |

| | |
|---|---|
| **IMPORTANT** | For Kinetix 5300, Tamagawa and Nikon Serial feedback types are not available for use with custom motors. These feedback types are shown as valid feedback devices for use with unlisted Kinetix motors. |




7. Complete the feedback configuration by entering the data obtained from your encoder manufacturer.

8. If the Load Feedback Configuration is used, navigate to Module Properties > Motion > Associated Axes.

   The Load Feedback Device dropdown menu is shown. The Load Feedback Device is used as secondary feedback for loop closure depending on your selected control mode.

9. Select the port that is used for the Load Feedback Device by using the Load Feedback Device dropdown menu.

   The Kinetix 5300 can only use the Aux Feedback port as the Load Feedback Device. Table 17 shows compatible devices.

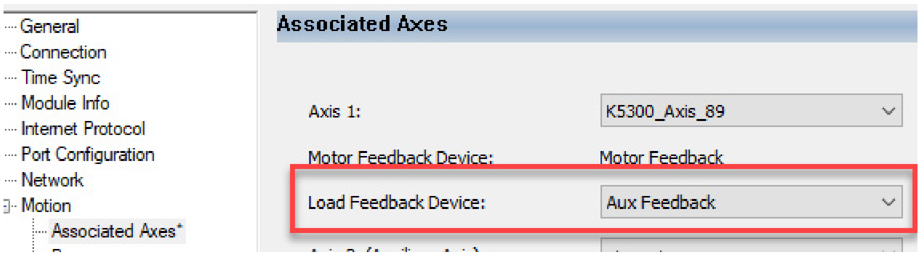
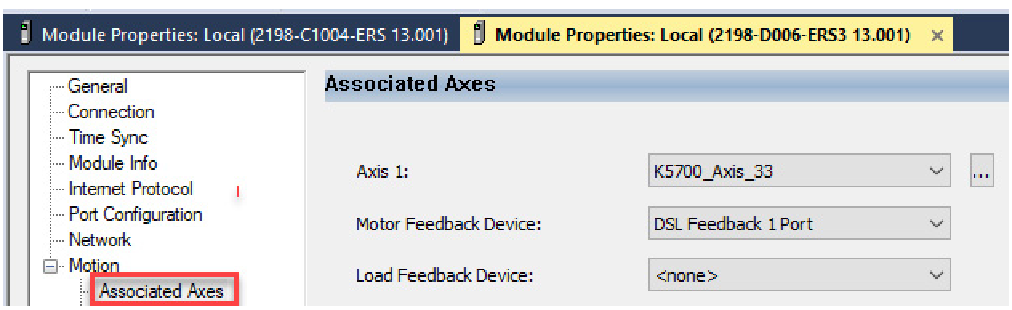



**Table 17 - Kinetix 5300 Feedback Device Support**

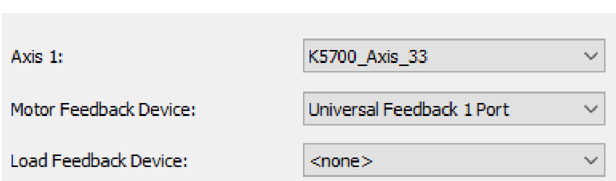
| Motor Feedback Port | Auxiliary Feedback Port |
|---|---|
| • Nikon (24-bit) serial (Kinetix TLP motors)<br>• Hiperface<br>• Tamagawa (17-bit) serial (Kinetix TL/TY motors)<br>• Generic TTL Incremental<br>• Generic Sine/Cosine Incremental | Generic TTL Incremental |

### *Kinetix 5700 - Configure the Universal Feedback Port*

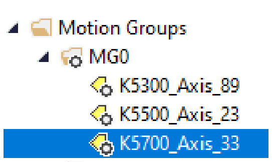
1. Right-click a Kinetix 5700 drive module in the Controller Organizer and choose Properties.
2. Navigate to Module Properties > Motion > Associated Axes.
3. Assign your Motion Axis (from the Motion Group) to Axis 1 by using the Axis 1 dropdown menu.



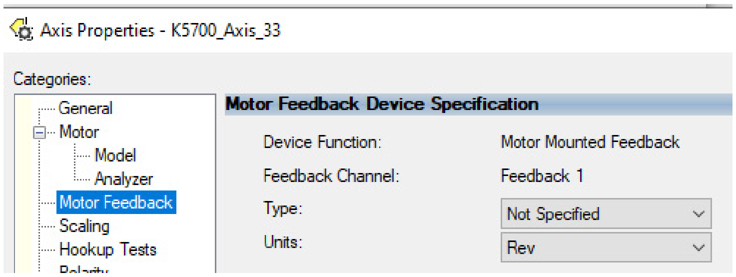

4. Assign the Universal Feedback Port 1 to Axis 1 by using the Motor Feedback Device dropdown menu. This setting represents the motor-mounted Feedback Device.




5. In the Motion Group, double-click the axis that was selected in step 3.

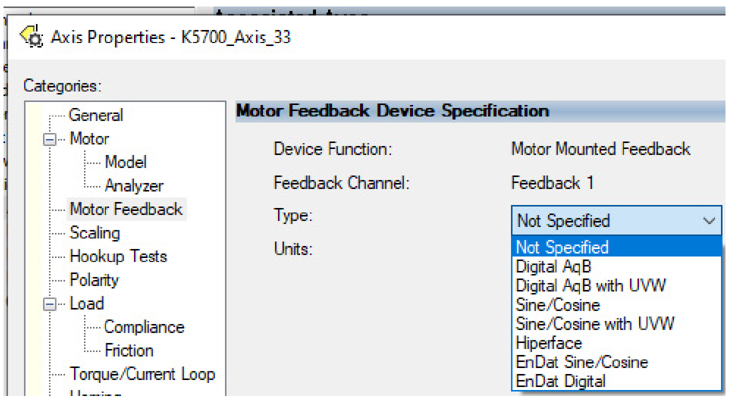


6. Navigate to Axis Properties > Motor Feedback.



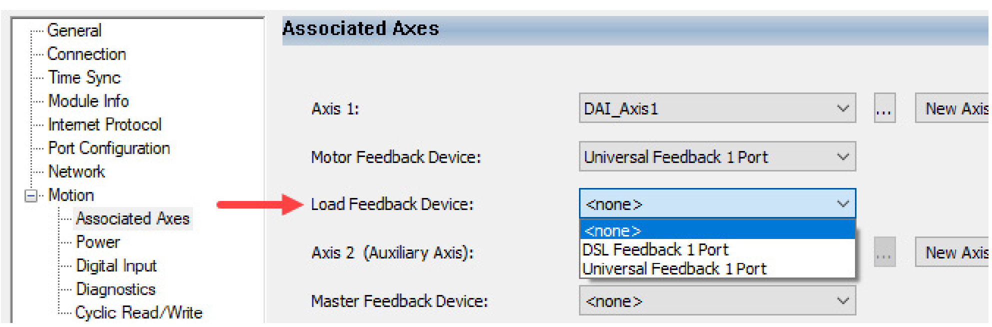

7. Choose your feedback type from the Type dropdown menu.

**IMPORTANT** Not all of the feedback types that are listed in the Type menu are available for all the control modes. See Table 2 on page 5 for drive, motor, and feedback compatibility. This compatibility will be validated once you download your project into the controller.




8. Complete the feedback configuration by entering the data obtained from your encoder manufacturer.
9. If the Load Feedback Configuration is used, navigate to Module Properties > Motion > Associated Axes.

   The Load Feedback Device is used as secondary feedback for loop closure depending on your selected control mode.



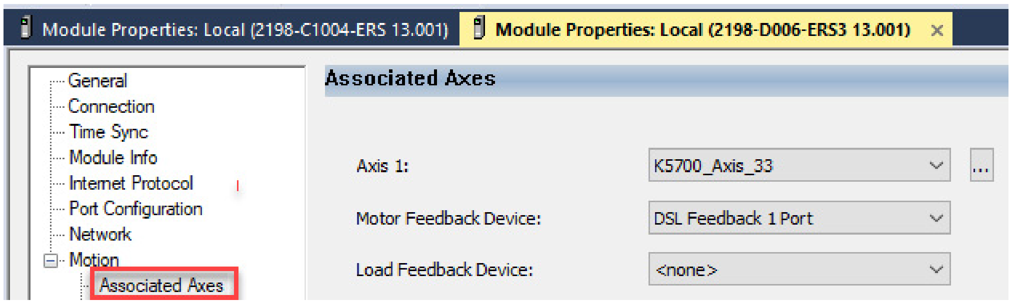

10. Select the port that is used for the Load Feedback Device by using the Load Feedback Device dropdown menu.

    The Kinetix 5700 can use either the Universal Feedback 1 Port or the DSL Feedback 1 Port as the Load Feedback Device.

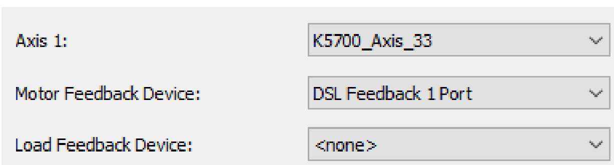
## Configure the DSL Feedback Port

The Kinetix 5700 drive supports DSL feedback for custom motor configuration. The Kinetix 5300 does not support DSL feedback.

1. Right-click a Kinetix 5700 drive module in the Controller Organizer and choose Properties.
2. Navigate to Module Properties > Motion > Associated Axes.
3. Assign your Motion Axis (from the Motion Group) as Axis 1 using the Axis 1 dropdown menu.

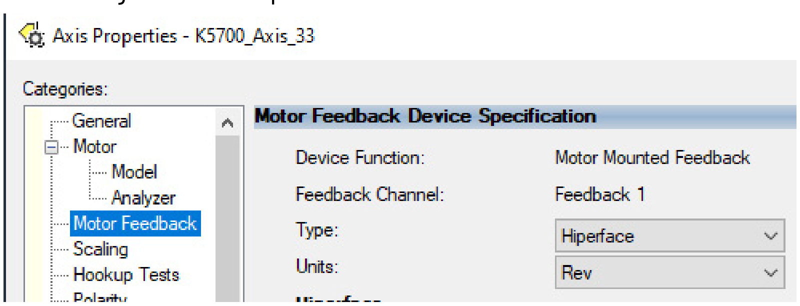



4. Assign the DSL Feedback Port to Axis 1 by using the Motor Feedback Device dropdown. This setting represents the motor-mounted Feedback Device. The Kinetix 5700 must use the DSL Feedback 1 Port.




5. In the Motion Group, double-click the axis that was selected in step 3.


6. Navigate to Axis Properties > Motor Feedback.




7. From the Type dropdown menu, select Hiperface.

| | |
|---|---|
| **IMPORTANT** | When the feedback type is set to Hiperface, the 2198-H2DCK converter kit must be used to integrate Hiperface encoder feedback. |

| | |
|---|---|
| **IMPORTANT** | The Type dropdown menu includes an option for Hiperface DSL. Hiperface DSL is only used with the Kinetix VPx family of motors (Kinetix VPL, VPC, VPF, and VPS). These motors include a programmed encoder and are not available for use with custom motors. |

# Hookup Tests Category

The Hookup Tests category provides tests to verify that your motor responds correctly to commands from the drive.

**Table 18 - Hookup Test Definitions**

| Hookup Test | Definitions |
|---|---|
| Marker | Verifies feedback device marker detection capability as you manually rotate the motor shaft. The test completes when the drive either detects the marker or when the motor moves the distance that is specified in the Test Distance field. If the marker remains undetected and the test completes successfully, it means that the motor moved the full test distance. If the marker remains undetected and the test fails, the motor did not move the full test distance. Run this test after running the Motor Feedback and Motor and Feedback tests. |
| Commutation | Verifies the commutation offset and commutation polarity of the motor. This test applies to third-party or custom permanent-magnet motors that are equipped with (TTL with Hall and Sine/Cosine with Hall) incremental encoders that are not available as a catalog number in the Motion Database. See Commutation Test on page page 30. |
| Motor Feedback | Verifies that feedback connections are wired correctly as you manually rotate the motor shaft. The test completes when the drive determines that the motor moved the full distance that is specified in the Test Distance field. Run this test before the Motor and Feedback Test to verify that the feedback can be read properly. Successful execution of this test results in updates to AxisProperties > Polarity settings. These settings are affected by the results of this test. |
| Motor and Feedback | Verifies that motor power and feedback connections are wired correctly as the drive commands the motor to rotate. Because the drive is rotating the motor, this test requires main power to be applied to the drive to run. Run the Motor Feedback test before running this test to verify that the feedback is being read correctly. Successful execution of this test results in updates to AxisProperties > Polarity settings. These settings are affected by the results of this test. This test is not available for use with rotary induction motors. |

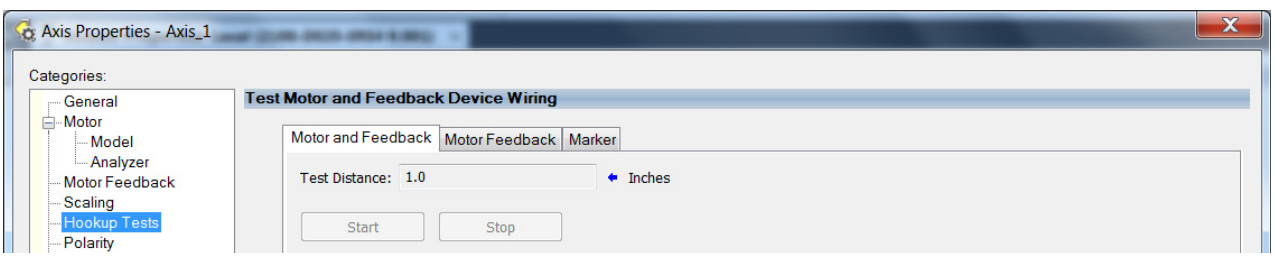
**IMPORTANT** A rotary or linear surface permanent-magnet motor needs alignment of the rotor. Failure to do so causes improper current control in the drive. Improper current control leads to improper velocity control, which leads to improper position control.

## Rotary Induction Motor

You must only perform the individual Marker and Motor Feedback tests. Rotary induction-motors do not require a Commutation test. Induction motors do not use any commutation offset because there is no need to align the rotor shaft to motor stator poles based on induction motor technology.

**IMPORTANT** When using a rotary induction motor, do not attempt to use the Motor and Feedback test. For the rotary induction motor type, this test is not available.

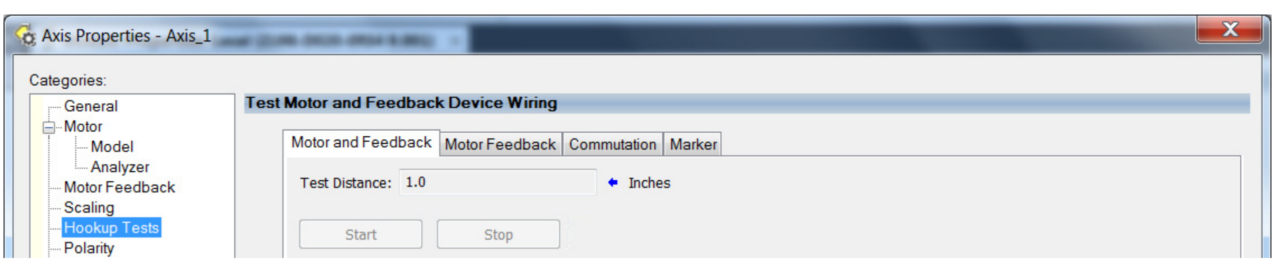
**Figure 25 - Rotary Induction Motor Hookup Tests**




## Permanent-magnet Motor

It is recommended to perform all hookup tests for Permanent-magnet (PM) motor types.

**Figure 26 - Permanent-magnet Motor Hookup Tests**



## Commutation Test

The commutation test determines an unknown commutation offset and can also be used to determine the unknown polarity of the start-up commutation wiring. You can also use the commutation test to verify a known commutation offset and the polarity start-up commutation wiring.

| | |
|---|---|
| **IMPORTANT** | This test applies to third-party or custom permanent-magnet motors that are equipped with any feedback device type listed as compatible with Kinetix 5700 drives that are not available as a catalog number in the Motion Database. |

| | |
|---|---|
| **IMPORTANT** | When motors have an unknown commutation offset and are not listed in the Motion Database by catalog number, you cannot enable the axis. |

The commutation test can be run either from Hookup Tests > Commutation tab (Figure 27) or Motor Feedback - Commutation section (Figure 28). The drive must be configured and main power must be applied to the drive before you can begin the commutation test.

**Figure 27 - Hookup Tests Category - Commutation Tab**

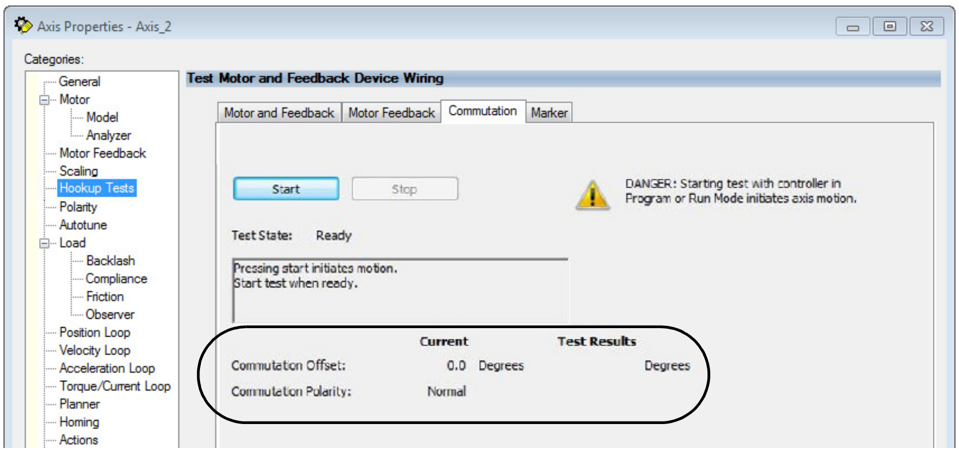
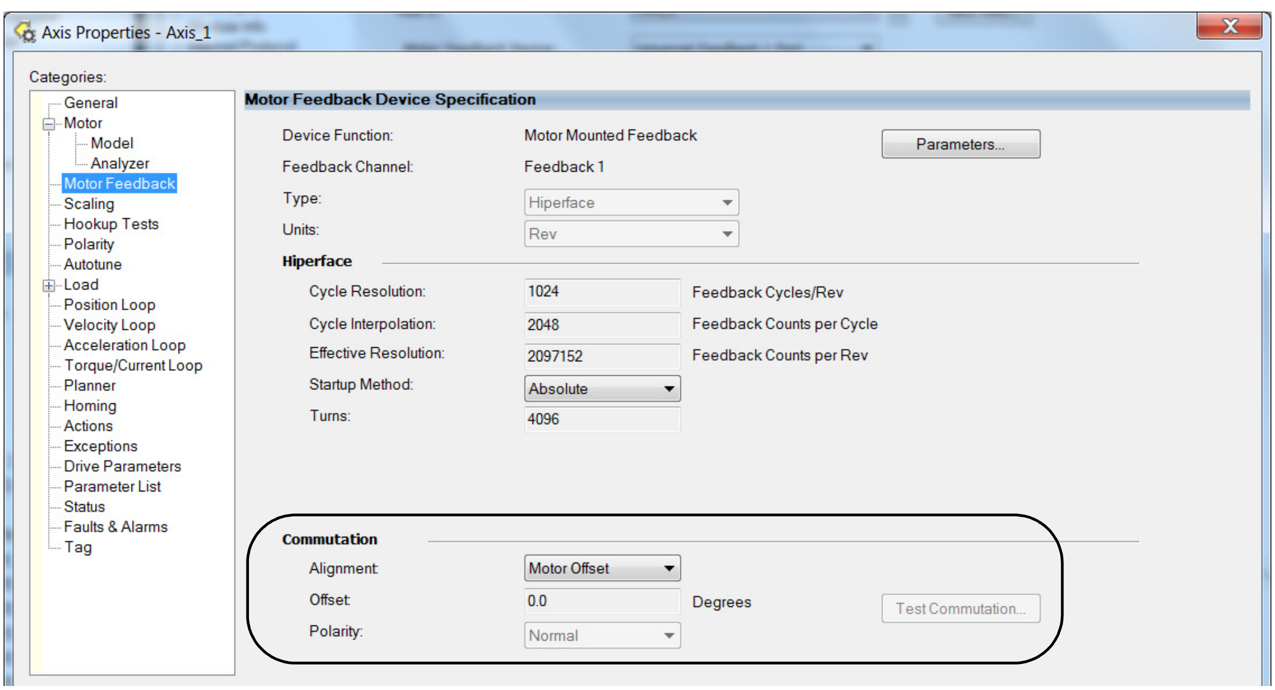
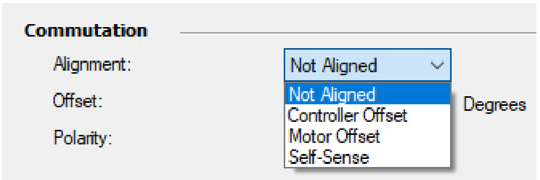



**Figure 28 - Motor Feedback Category - Commutation Section**



There are four types of commutation alignment: Not Aligned, Controller Offset, Motor Offset, and Self-Sense.

**Figure 29 - Motor Feedback Category - Commutation Alignment Options**




In addition to the Commutation Alignment Definitions table here, see Table 2 on page 5, which shows the different drive, motor, and feedback devices and the different types of commutation alignment that are supported.

**Table 19 - Commutation Alignment Definitions**

| Alignment Method | Definitions |
|---|---|
| Motor Offset | The Motor Offset method is used with a programmed encoder. For example, a Kinetix MPL-B310P-MJ72AA with intelligent feedback. The encoder stores an internal offset, which is seen in the examples on page 30 with 0 degrees. This offset is for use when the position loop is closed and the drive is enabled. |
| Not Aligned | Not Aligned means no motor-rotor alignment is used. This method is used when a rotary or linear SPM motor starts (the drive senses no alignment and therefore the drive state goes to Start Inhibit). Commutation is not configured in the motor. |
| Controller Offset | When the optional Commutation Alignment attribute is supported by the feedback device and set to Controller Offset, the drive applies the Commutation Offset value from the controller to determine the electrical angle of the motor. In this case, a valid Commutation Offset value must be entered by the user, read from the Motor Database, or determined by the Commutation Test. |
| Self-Sense | When using incremental encoders either AqB or Sin/Cos, the drive automatically sets the Alignment as Self-Sense. When the drive is first enabled, the motor aligns with the magnetic and electric poles. The commutation offset is calculated at that time. This value is retained until the drive is disconnected or power is cycled. The Self-Sense algorithm is described in the Kinetix 5700 Servo Drives User Manual, publication 2198-UM002. |

When running the commutation test for a permanent-magnet motor, it is recommended that the motor not be connected to any transmission, gearbox, or load whatsoever.

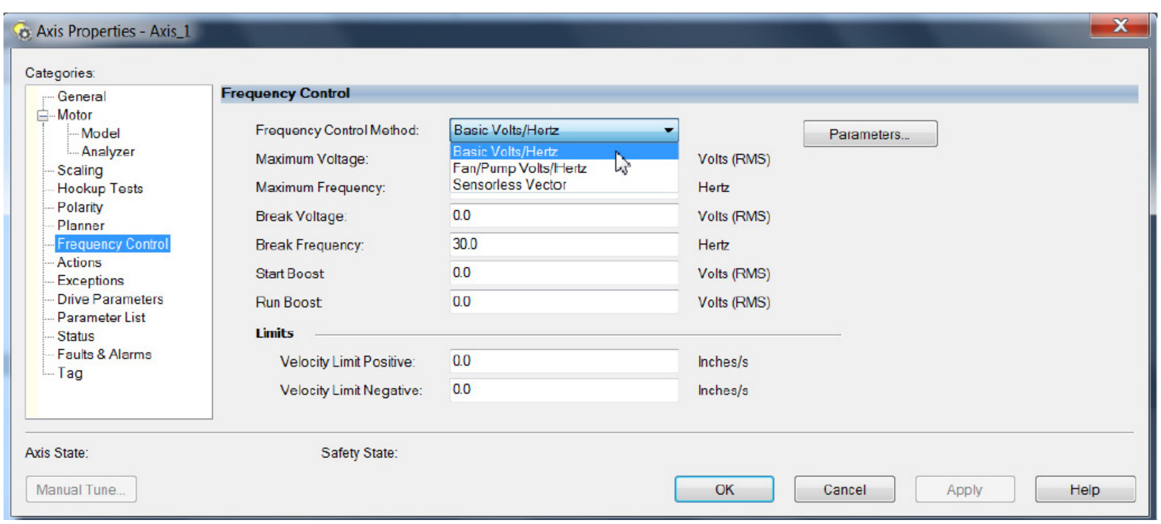
During a commutation test, the Kinetix 5300 or 5700 drive senses the motor feedback and aligns the motor rotor magnet to the stator. During a commutation test for a rotary permanent-magnet motor, it is normal to see a motor rotation of 1/n revolutions. This is based on the equation where 2^n = number of poles. For example, with an eight pole motor the commutation test normally rotates 1/3 of a motor revolution (2^3 = 8 poles and 1/3 of a revolution is performed) to verify the accuracy of the calculated offset.

Once completed, the controller offset populates and is used on each power cycle for correct control.

# Frequency Control Category

Use the Frequency Control category for induction motor open-loop control. When you configure a Frequency Control Method, no motor feedback is used. Frequency control methods consist of Basic Volts/Hz, Sensorless Vector, and Fan/Pump Volts/Hz.

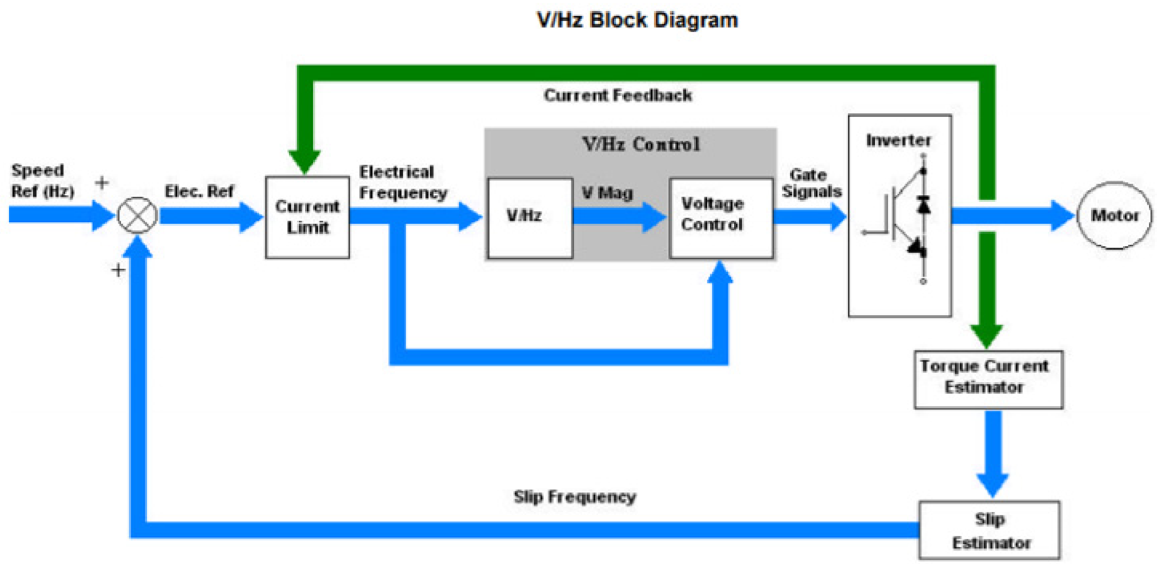
**Figure 30 - Frequency Control Methods**



## Basic Volts/Hertz Method

The Basic Volts/Hertz control method applies voltage to the motor generally in direct proportion to the commanded frequency or speed. By maintaining a constant volts/hertz ratio, the drive can control the speed of the connected motor.

**Figure 31 - Volts/Hertz Block Diagram**



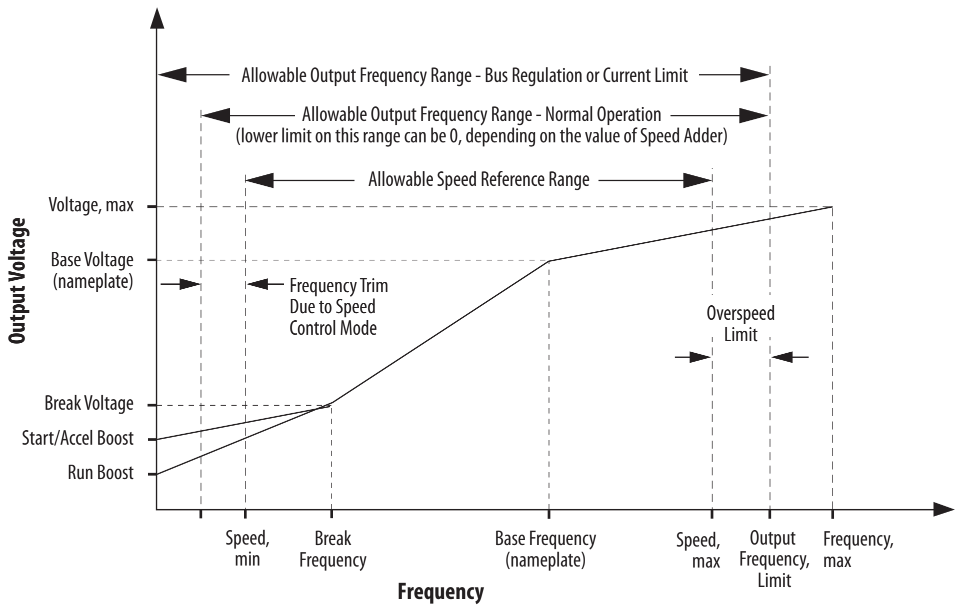

Typically, a current limit block monitors motor current and alters the frequency command when the motor current exceeds a predetermined value. The volts/hertz block converts the current command into a volts/hertz ratio. It supplies a voltage magnitude command to the voltage control block. The angle of the voltage magnitude determines where the voltage should be relative to the current. This determines flux current to the motor. If this angle is incorrect, the motor can become unstable. Because the angle is not controlled in a volts/hertz drive, you can expect poor performance or even instability at low speeds. An additional feature in new drives, Slip Compensation, has improved the speed control. It alters the frequency reference when the load changes to keep the actual motor speed close to the desired speed.

While this type of control is satisfactory for many applications, it is not well suited to some applications, including the following:

- applications that require higher dynamic performance
- applications where the motor runs at very low speeds
- applications that require direct control of motor torque rather than motor frequency

The ability of the motor to maintain high torque output at low speed drops off significantly below 3 Hertz. This is a normal characteristic of a motor using Volts/Hertz control mode and is one of the reasons that the operating speed range for Volts/Hertz control is typically around 20:1. As the load is increased, the motor speed drops off. This relationship is not an indication of starting torque. This relationship shows only the ability of the drive to maintain torque output over a long period.

**Figure 32 - Custom Volts/Hertz Curve**



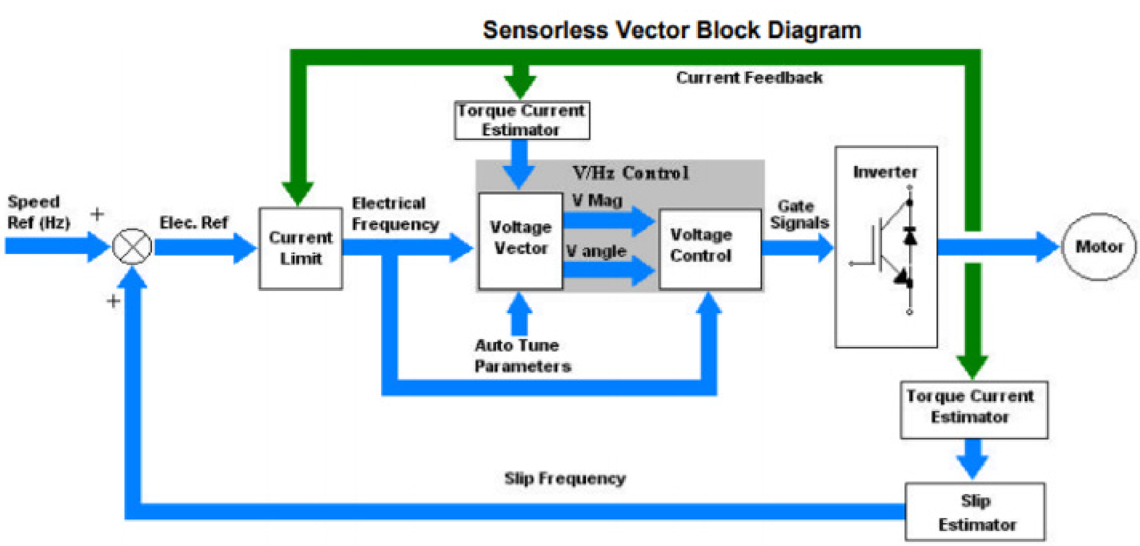

The volts/hertz curve can be adjusted by using break frequency and break voltage to alter the linear curve. See Fan/Pump Curve on page 34 for that curve.

## Sensorless Vector Method

The Sensorless Vector method enhances the basic Volts/Hertz algorithm by using current vectors Iq (torque-producing current) and Id (flux current) for superior control at low speeds. Sensorless vector control, like volts/hertz control, continues to operate as a frequency control drive with slip compensation keeping actual motor speed close to the desired speed. The Torque Current Estimator block determines the percent of current that is in-phase with the voltage, providing an approximate torque current. This is used to estimate the amount of slip, providing better speed control under load.

The control improves upon the basic Volts/Hertz control method by providing both a magnitude and angle between the voltage and current. Volts/Hertz control only controls the voltage magnitude. Voltage angle controls the amount of motor current that goes into motor flux. This functionality is enabled by the Torque Current Estimator. By controlling this angle, low-speed operation and torque control are improved over the standard Volts/Hertz control.

**Figure 33 - Sensorless Vector Block Diagram**



## Fan/Pump Volts/Hertz Method

The Fan/Pump Volts/Hertz method is based on the Basic Volts/Hertz, but is tailored for fan/pump applications. When this frequency control method is selected, the linear ability for break voltage, break frequency, and start boost (basically a Volts offset) is no longer specified because the curve is exponentially increasing.

**Figure 34 - Fan/Pump Curve**

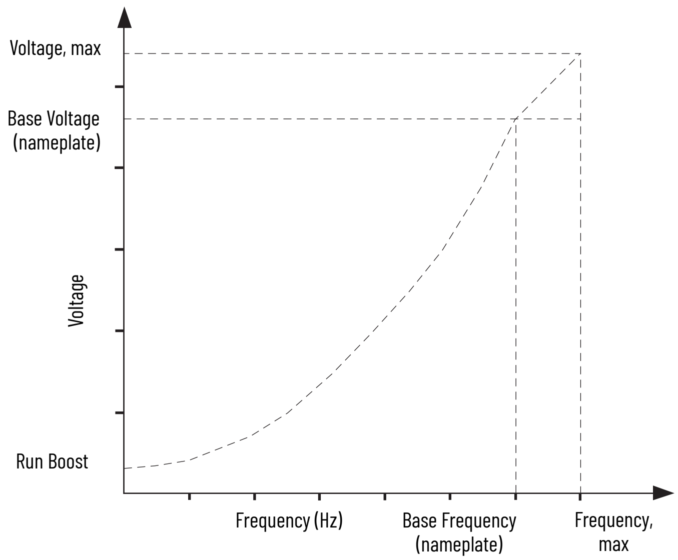
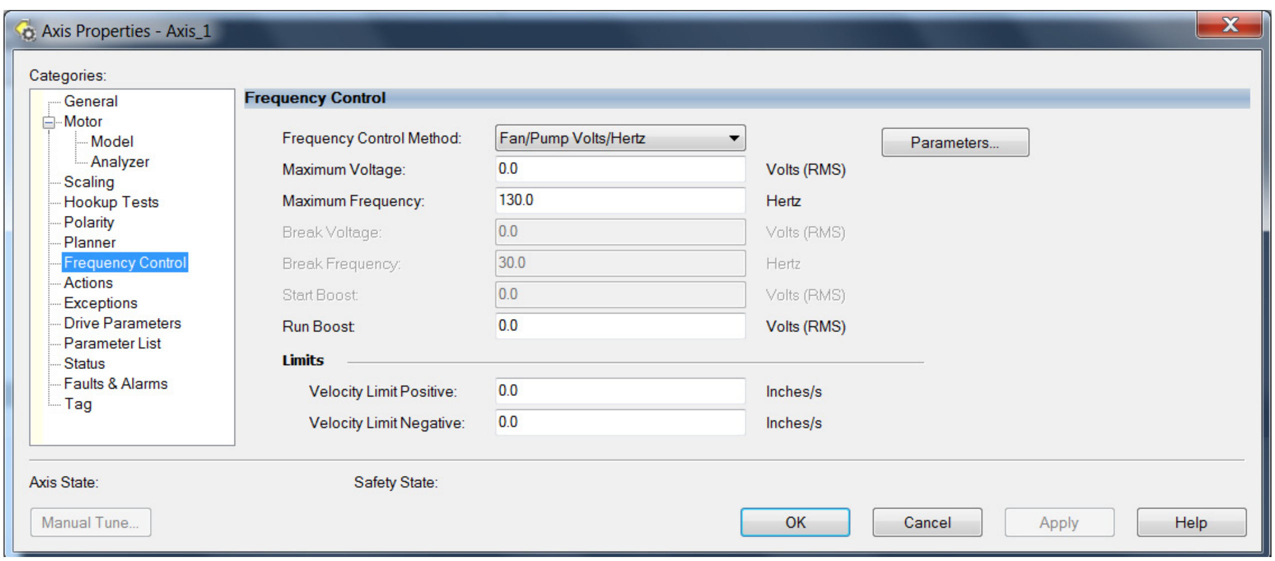



**Figure 35 - Fan/Pump Configuration**

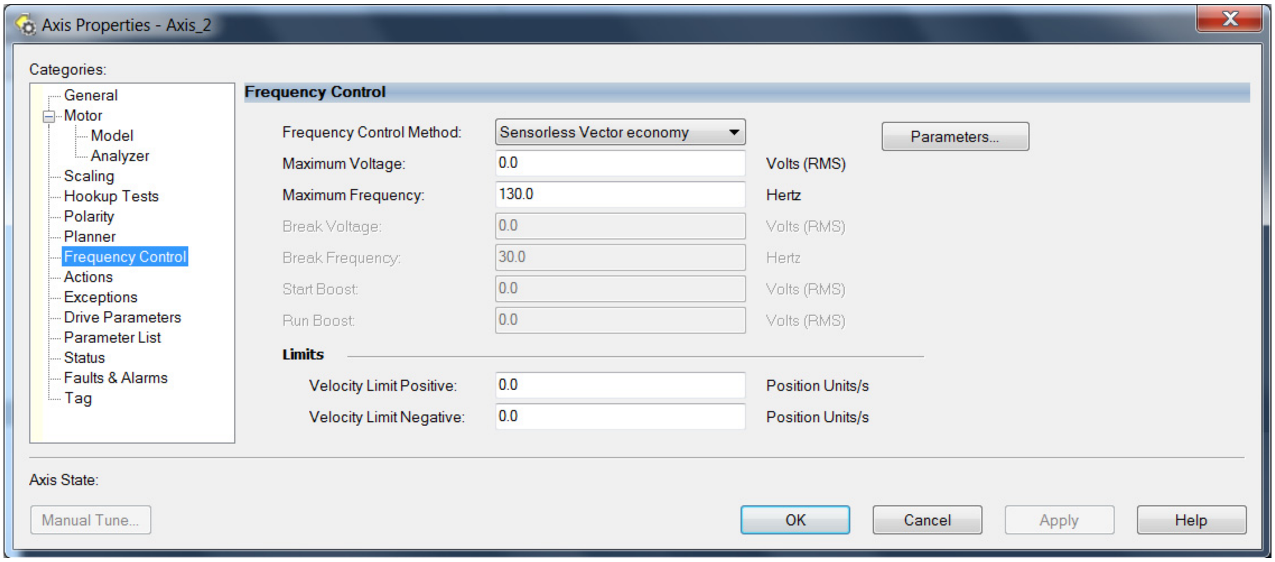


## Sensorless Vector Economy Method

The Sensorless Vector Economy method is available with PowerFlex drives that are configured to be used with Integrated Motion on Ethernet/IP (CIP motion) drives. Sensorless vector economy applies to the sensorless vector algorithm, but seeks to reduce energy consumption when the applied load is less than 50% of rating.

| | |
|---|---|
| **IMPORTANT** | Kinetix 5700 servo drives do not support the sensorless vector economy method. |

**Figure 36 - Sensorless Vector Economy Configuration**

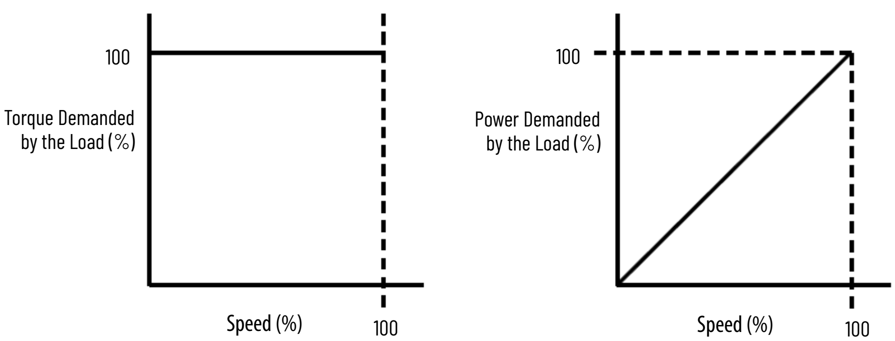



## Frequency Control Method Selection

Constant Torque, Variable Torque, and Constant Horsepower are frequency control method options.

The torque that is demanded by the load is constant throughout the speed range. Constant torque load types are essentially friction loads. Figure 37 shows the constant torque and its effect on horsepower demanded by the load.

**Figure 37 - Constant Torque Load**



Because power is a product of torque multiplied by the speed, and torque remains constant in this type of load, horsepower is a function of speed, as described in the following equations and definitions.

$$\text{Hp} = \frac{\text{Torque} \bullet \text{Speed}}{5252} \quad \text{OR} \quad \text{Watts} = \frac{\text{Torque} \bullet \text{Speed}}{9.55}$$

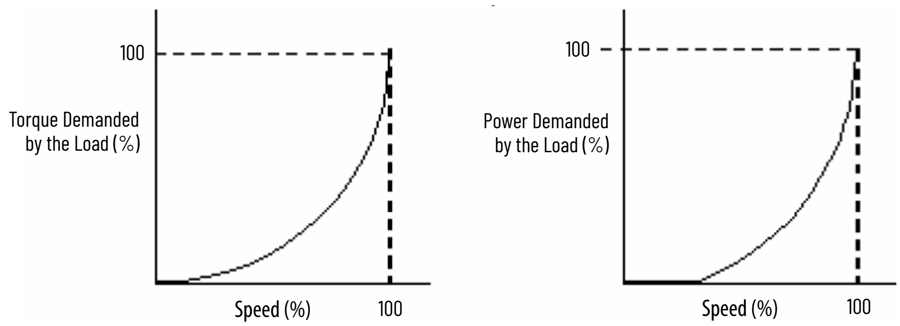
Where:

| Torque Demanded by the Load | Power Demanded by the Load |
|---|---|
| Torque = lb•ft | Torque = N•m |
| Speed = RPM | Speed = RPM |
| 5252 = a proportionality constant | 9.55 = a proportionality constant |

Examples of constant torque loads are conveyors and extruders. Constant torque is also used when shock loads, overloads, or high inertia loads are encountered.

With variable torque loads, the torque demand increases with speed, usually speed squared (Speed$^2$). Horsepower is typically proportional to speed cubed (Speed$^3$).

**Figure 38 - Variable Torque Load**




Examples of loads that exhibit variable torque characteristics are centrifugal fans, pumps, and blowers. This type of load requires much lower torque at low speeds than at high speeds.

- Use the Basic Volts/Hertz method in fans, pumps, and blower applications
- Use the Fan/Pump Volts/Hertz method for fan and pump applications
- It is also possible to use velocity or torque loop (with encoder) for more demanding applications

Constant horsepower operation is a function of the motor being operated above base motor speed. The horsepower demanded by the load is constant within the speed range. The speed and torque are inversely proportional to each other.

**Figure 39 - Constant Horsepower Load**

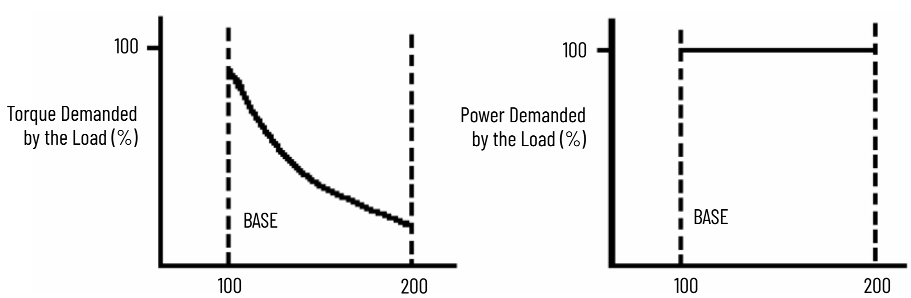


Table 20 recommends frequency control methods based on application requirements. Other frequency control methods than those shown can work, but the table provides general guidelines. Table 21 on page 37 provides guidelines about the characteristics of various applications, which can be used to determine the application requirements.

### Table 20 - Frequency Control Method Guidelines

| Application Requirement | Control Method |
|---|---|
| Variable torque (VT) less than 20:1 speed range | Basic Volts Per Hertz or Fan/Pump Volts Per Hertz generally with an induction motor |
| Constant torque (CT) less than 40:1 speed range | Sensorless Vector with an induction motor |
| CT with speed range to 100:1 | Position or Velocity Loop with encoder induction or SPM motor based on acceleration requirements/size |
| CT with needs for position control | Position loop with encoder with induction motor or SPM motor based on acceleration requirements/size |
| High acceleration and deceleration | Use of an SPM motor, linear or rotary motor |
| Winder/Unwinder type control | Use of Velocity loop with encoder and SLAT min/max |

### Table 21 - Application Matrix

| | Load Characteristics | | | | Speed and Torque Characteristics | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Application** | **Friction** | **Gravity** | **Fluid** | **Inertia** | **Constant Torque** | **Variable Torque** | **Speed Range** | **Regen/ Braking** | **Regulation Type(1)** |
| Agitators | X | — | — | — | X | — | 30:1 | — | S |
| Braider | — | — | — | X | X | — | 10:1 | — | S |
| Can Making | X | — | — | — | X | — | 15:1 | X | S |
| Centrifugal Fans | — | — | X | — | — | X | 4:1 | X | S |
| Centrifugal Fans (I D) | — | — | X | — | — | X | 10:1 | X | S |
| Centrifugal Pumps | — | — | X | — | — | X | 3:1 | — | S |
| Centrifuge | — | — | — | X | X | — | 30:1 | X | S |
| Coaters | X | — | — | — | X | — | 4:1 | X | S/T |
| Coilers | — | — | — | X | X | — | 60:1 | X | S/T |
| Compressors / Reciprocating | X | — | — | — | X | — | 10:1 | — | S |
| Compressors / Screw Type | X | — | — | — | X | — | 10:1 | — | S |
| Conveyors (Auger) | X | — | — | — | X | — | 20:1 | — | S |
| Conveyors (Belt) | X | — | — | — | X | — | 30:1 | X | S |
| Conveyors (Chain Type/load Share) | X | — | — | — | X | — | 40:1 | X | S/T |
| Conveyors (Vibratory) | — | — | — | X | X | — | 10:1 | — | S |
| Cut To Length | X | — | — | — | X | — | 100:1 | X | S/P |
| De-barkers | — | — | — | X | X | — | 20:1 | X | S |
| Diverters | — | — | — | X | X | — | 40:1 | — | S |
| Dryers | — | — | X | — | — | X | 10:1 | — | S |
| Edge Trimmer | X | — | — | — | X | — | 15:1 | X | S |
| Elevators | — | X | — | — | X | — | 100:1 | X | S/T |
| Extruders | X | — | — | — | X | — | 60:1 | — | S/T |
| Feeders | X | — | — | — | X | — | 4:1 | — | S |
| Floculators | X | — | — | — | X | — | 10:1 | — | S |
| Flying Cut Off | X | — | — | — | X | — | 100:1 | X | S/P |
| Gantry Type Cranes and Hoists | X | X | — | X | X | — | 100:1 | X | S/T |
| Grinders | — | — | — | X | X | — | 10:1 | X | S |
| Hoists | — | X | — | — | X | — | 100:1 | X | S/T |
| HVAC | — | — | X | — | — | X | 3:1 | — | S |
| Indexers | X | — | — | — | X | — | 20:1 | — | S/P |
| Injection Molding | X | — | — | — | X | — | 40:1 | — | S/T |
| Kiln Drives | — | — | — | X | X | — | 10:1 | X | S |
| Lift Applications | — | X | — | — | X | — | 100:1 | X | S/T |
| Line Shaft | X | — | — | — | X | — | 10:1 | X | S/T |
| Mill / Ball Type | — | — | — | X | X | — | 10:1 | X | S |
| Mill / Machining Type | X | — | — | — | X | — | 100:1 | X | S/P |

**Table 21 - Application Matrix (Continued)**

| | Load Characteristics | | | | Speed and Torque Characteristics | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Application** | **Friction** | **Gravity** | **Fluid** | **Inertia** | **Constant Torque** | **Variable Torque** | **Speed Range** | **Regen/ Braking** | **Regulation Type(1)** |
| Mill / Plate Type | – | – | – | X | X | – | 10:1 | X | S/T |
| Mill / Rod Type | – | – | – | X | X | – | 10:1 | X | S/T |
| Mixers (Rotating Beater) | X | – | – | – | X | – | 4:1 | – | S |
| Mixers / Banbury | X | – | – | – | X | – | 10:1 | – | S/T |
| Monorails | X | – | – | – | X | – | 10:1 | X | S |
| Packaging Equipment | X | – | – | – | X | – | 20:1 | X | S/P |
| Palletizers | X | X | – | – | X | – | 10:1 | X | S/P |
| Positioning | X | – | – | X | X | – | 100:1 | X | P |
| Positive Displacement Blowers / Pumps | X | – | – | – | X | – | 10:1 | – | S |
| Press / Blanking Type | – | – | – | X | X | – | 30:1 | X | S |
| Press / Punch Type | – | – | – | X | X | – | 30:1 | X | S |
| Press / Reciprocating | – | – | – | X | X | – | 10:1 | X | S |
| Press Feeders | X | – | – | – | X | – | 60:1 | X | S |
| Rolling Mills | X | – | – | – | X | – | 10:1 | X | S |
| Rotary Tables | – | – | – | X | X | – | 100:1 | X | S/P |
| Shakers | – | – | – | X | X | – | 10:1 | – | S |
| Slitter | X | – | – | – | X | – | 100:1 | X | S/T |
| Sorter | X | – | – | – | X | – | 40:1 | – | S |
| Spindles | – | – | – | X | X | – | 100:1 | X | S |
| Spray Painting | X | X | – | – | X | – | 40:1 | X | S |
| Stackers / Storage and Retrieval | – | X | – | – | X | – | 10:1 | X | S/P |
| Tension Reels | – | – | – | X | X | – | 100:1 | X | S/T |
| Tentering | X | – | – | – | X | – | 100:1 | X | – |
| Test Stands / Chassis (Dynamometer) | – | – | – | X | X | – | 100:1 | X | S/T |
| Test Stands / Engine | – | – | – | X | X | – | 100:1 | X | T |
| Test Stands / Generic | X | – | – | X | X | – | 100:1 | X | T |
| Test Stands / Transmission | – | – | – | X | X | – | 100:1 | X | T |
| Tower Type Cranes and Hoists | – | X | – | – | X | – | 100:1 | X | S/T |
| Transfer Line | X | – | – | – | X | – | 10:1 | X | S |
| Unwinder (For Web / Wire) | – | – | – | X | X | – | 100:1 | X | S/T |
| Web Calendaring | – | – | – | X | X | – | 100:1 | X | S/T |
| Web Coating | – | – | – | X | X | – | 100:1 | X | S/T |
| Web Pickling | – | – | – | X | X | – | 20:1 | X | S/T |
| Wind Tunnels | – | – | X | – | – | X | 4:1 | – | S |
| Winder (For Web / Wire) | – | – | – | X | X | – | 100:1 | X | S/T |
| Wire Drawing | X | – | – | – | X | – | 40:1 | X | S/T |

(1) Regulation types: Speed (S), Torque (T), Position (P)

# Motor Nameplate Datasheet Entry Configurations

This section contains several examples that include induction motors with and without encoder and surface permanent-magnet for rotary and linear applications.

**Table 22 - Motor Nameplate Datasheet Entry Configuration Descriptions**

| Configuration | Description |
|---|---|
| Induction Motor Without Encoder Example | Induction motor in Frequency Control mode without an external encoder for motor feedback. |
| Induction Motor With Encoder Example | Induction motor in Position Loop mode with an external Digital AqB encoder for motor feedback. |
| Rotary Surface Permanent-magnet Motor Example | Rotary permanent-magnet motor in Position Loop mode with an external EnDat sine/cosine encoder for motor feedback. |
| Linear Surface Permanent-magnet Motor Example | Linear permanent-magnet motor in Position Loop mode with an external Digital AqB with UVW encoder for motor feedback. |

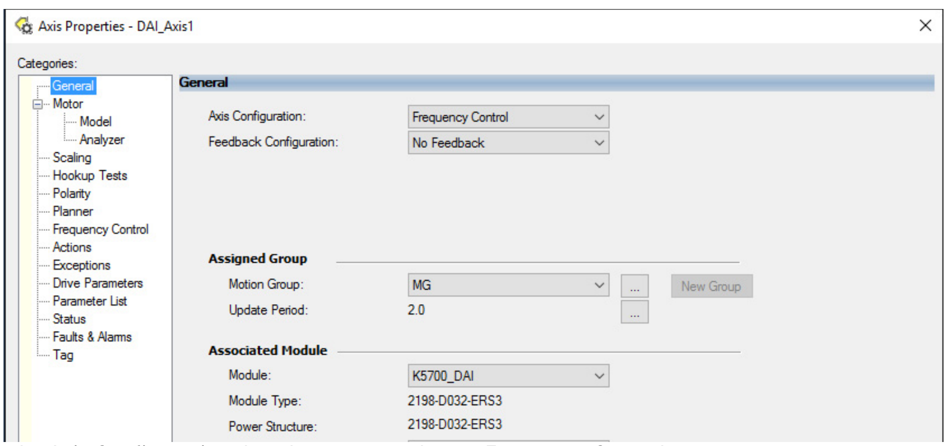
Kinetix 5300 and 5700 servo drives can operate induction motors using Open Loop control or Closed Loop control. Use the Frequency Control Method Guidelines table on page 37 and the Application Matrix table beginning on page 37 to determine which mode to use and at what frequency.

# Induction Motor Without Encoder Example

In this example, an induction motor is used in Frequency Control mode without a feedback device configured as motor feedback.

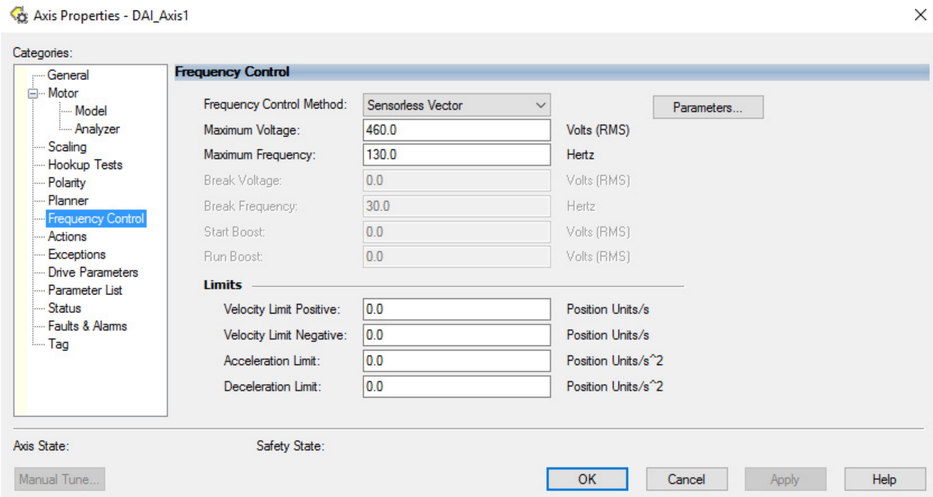
Follow these steps to enter nameplate data for an induction motor without an encoder.

1. In the Controller Organizer, right-click an axis and choose Properties.
   a. Select the General category.



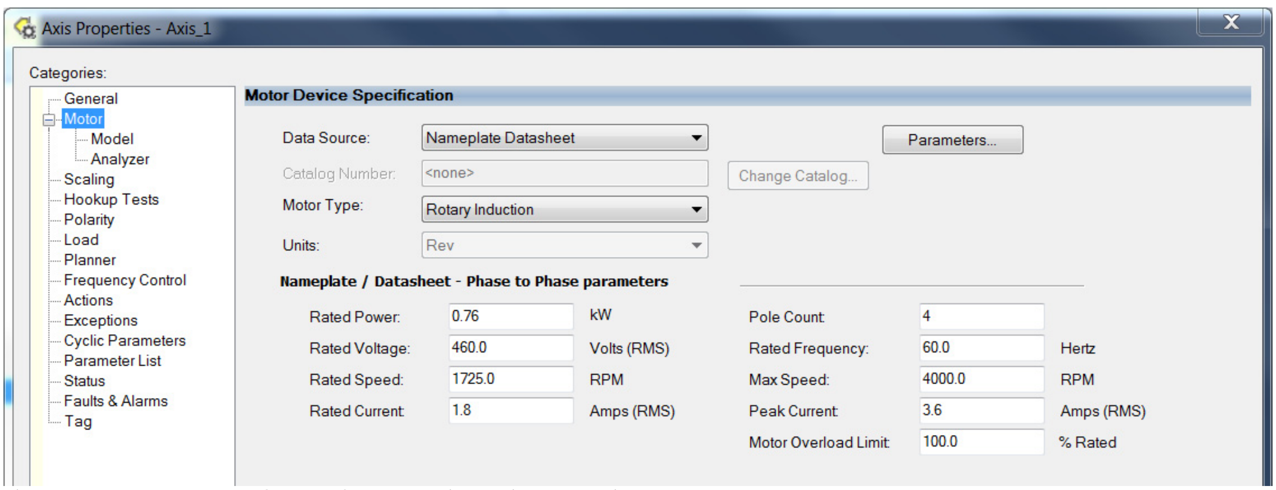

   b. From the Axis Configuration dropdown menu, choose Frequency Control.
   c. Click Apply.

2. Select the Frequency Control category.




a. From the Frequency Control Method dropdown menu, choose Sensorless Vector.
b. Click Apply.

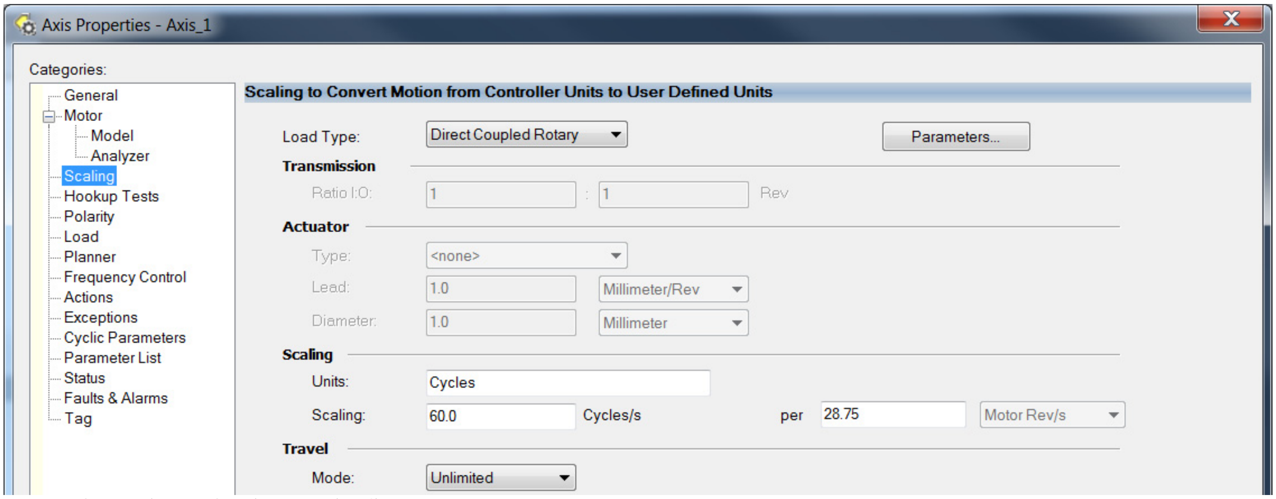
3. Select the Motor category.




In this example, a Marathon 56T17F5323J rotary induction motor is used.

a. From the Data Source dropdown menu, choose Nameplate Datasheet.
b. From the Motor Type dropdown menu, choose Rotary Induction.
c. Enter the phase to phase motor data from the motor nameplate or use the manufacturer's equivalent circuit diagram or performance sheet.
d. Click Apply.

4. Select the Scaling category.

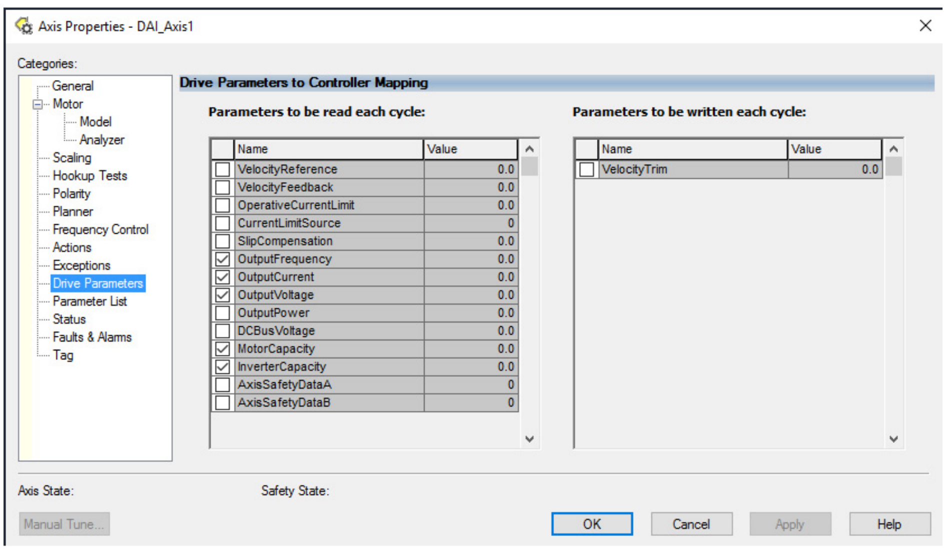



   a. Enter Cycles in the Scaling > Units field.
   b. For the Scaling attributes, enter 60.0 Cycles/s per 28.75 Motor Rev/s.

      We choose Cycles as units because Hertz (Hz) is often used as a speed reference. Motion Axis scaling units in this example are set up to represent speed, where cycles per second is Hertz (Hz).

   c. Click Apply.

5. Select the Drive Parameters category.
   a. Check (enable) the cycle read parameters as shown.




   b. Monitor the selected parameters using the Controller-based Axis tags.

      All motor parameter data that was entered will be retained. In Sensorless Vector mode, output current, output frequency, output voltage, motor capacity, and inverter capacity are suggested parameters to monitor when doing installation performance evaluation.

> If you would like to trend the parameters, see the Motion System Tuning Application Technique, publication MOTION-AT005, Appendix B to configure a trend specifically for motion control.

6. Go online with the controller and download your program.

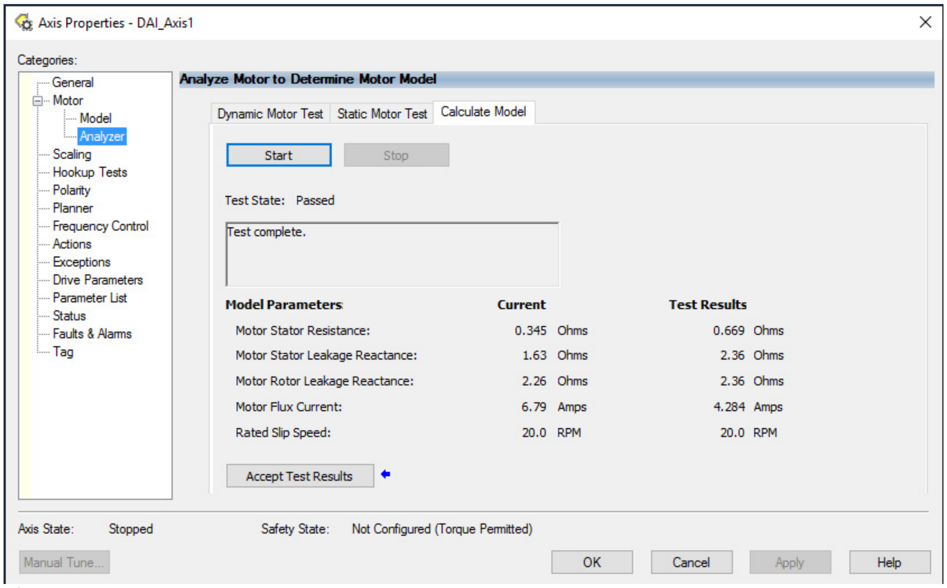
# Axis Properties - Online Tasks

In this section, you use the Motor > Analyzer category performance tests and Motion Direct Commands to produce missing motor specification values.

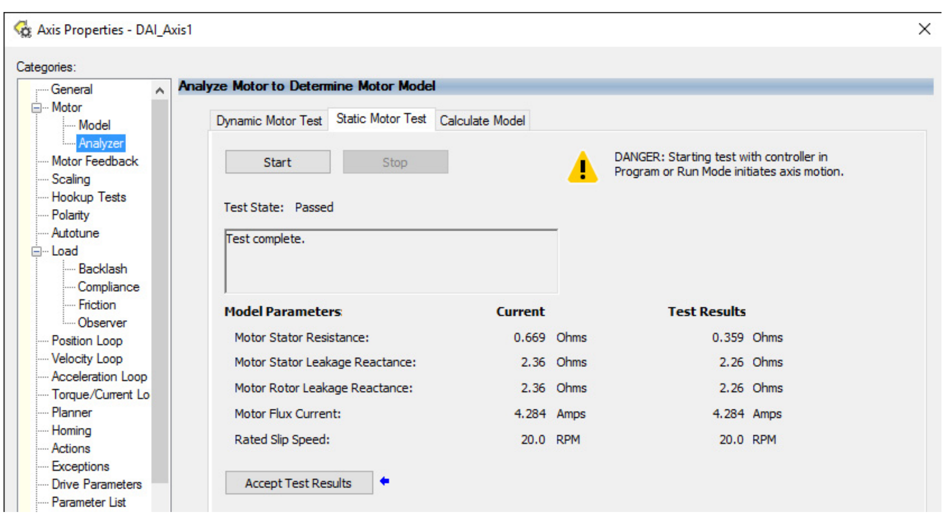
### *Configure the Motor > Analyzer Category*

At this point, the drive has main power applied but is not energized (enabled).

1. In the Controller Organizer, right-click your axis and choose Properties.
   a. Expand the Motor category and select Analyzer.




   b. Click the Calculate Model tab.
   c. Click Start. No movement occurs with this test.
   d. If the test completes, click Accept Test Results. If the test does not complete, see Calculate Model Test on page 69 for suggestions on next steps.
   e. Click Apply.
2. Click the Static Motor Test tab.




   a. Click Start. No movement occurs with this test.
   b. If the test completes, click Accept Test Results. If the test does not complete, see Static Motor Test on page 70 for suggestions on next steps.
   c. Click Apply.

### *Run Motion Direct Commands*

1. Select the Drive Parameters tab and monitor the parameters that you checked while offline (step 5 on page 41) while you execute Motion Direct Commands.
2. From the controller organizer, make sure that all safeguards are in place and use Motion Direct Commands to enable (MSO) the axis.

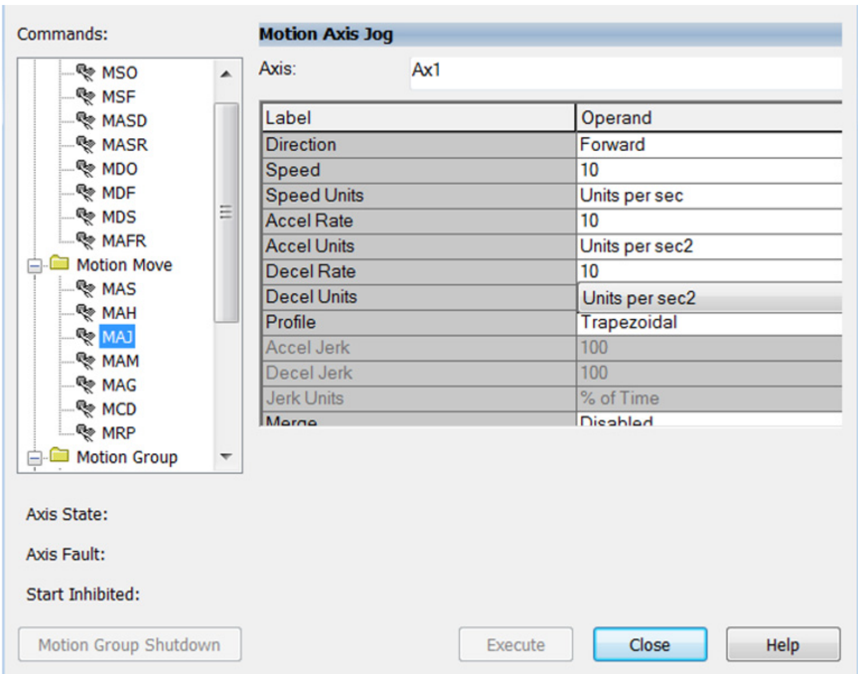
   Enabling the axis can generate unwanted movement if not configured properly.

   If the test does not complete, see Motion Direct Commands on page 73 for suggestions on next steps.
3. Use Motion Direct Commands to jog (MAJ) the axis. The MAJ (Motion Axis Jog) commands a constant velocity without termination. If this is problematic for your application, use an MAM (Motion Axis Move) instruction instead.

   If you created a trend, you can run it now.

   See Motion Direct Commands on page 73, for suggestions on next steps if the test does not complete.

   Use a 10 cycle per second speed or other based on your machine requirements. Use a 10 cycle per second$^2$ acceleration and deceleration or another acceptable value.



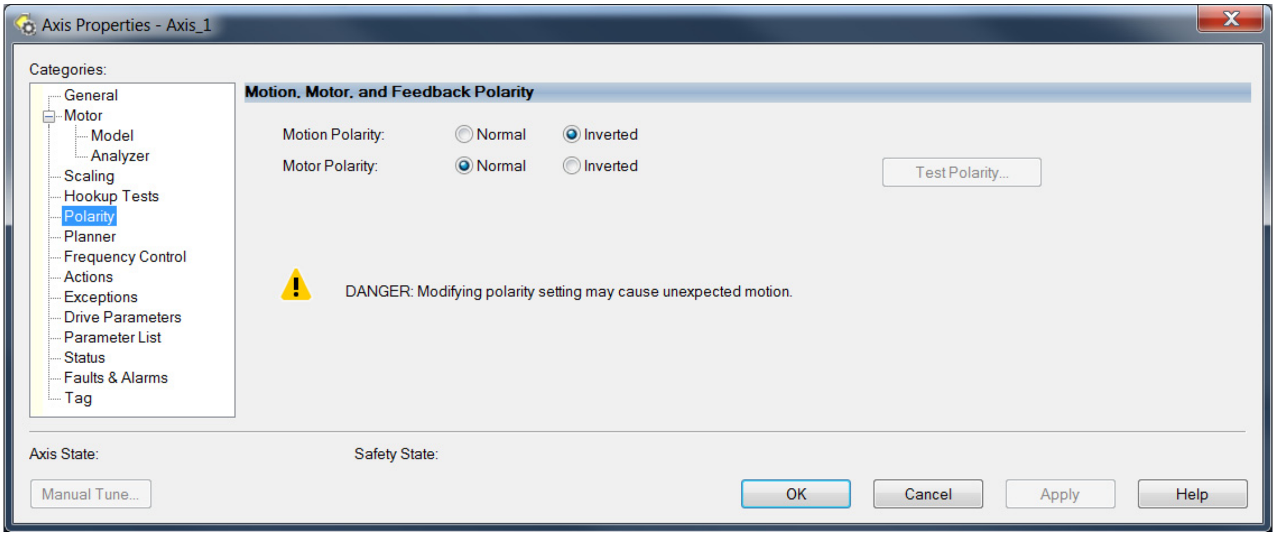

4. Click Execute.

   If the test does not complete, see Motion Direct Commands on page 73 for suggestions on next steps.
5. Observe the direction of rotation when the speed reference is positive (or Forward).
6. When you are satisfied with observing the motor direction of rotation, stop movement by executing an MAS (Motion Axis Stop) instruction.
7. When the movement has stopped, disable the drive by executing an MSF (Motion Servo Off) instruction.

*Set Motor Polarity*

1. Select the Polarity category.

   If the observed speed reference was negative (or Reverse), change the Motion Polarity setting to the opposite of what you observed based on the application need. In this example, Motion Polarity was changed from Normal to Inverted.




   Motor Polarity is used to switch the directional sense of the drive command and actual signal. Normal means that the motor rotates clockwise with a positive command. Inverted means that the motor rotates counterclockwise with a positive command.

2. Repeat step 1 through step 3 on page 43 and change the MAJ speed to change speeds and to verify performance.

   If the test does not complete or an unacceptable machine performance is observed, see Motion Direct Commands on page 73 for suggestions on next steps.

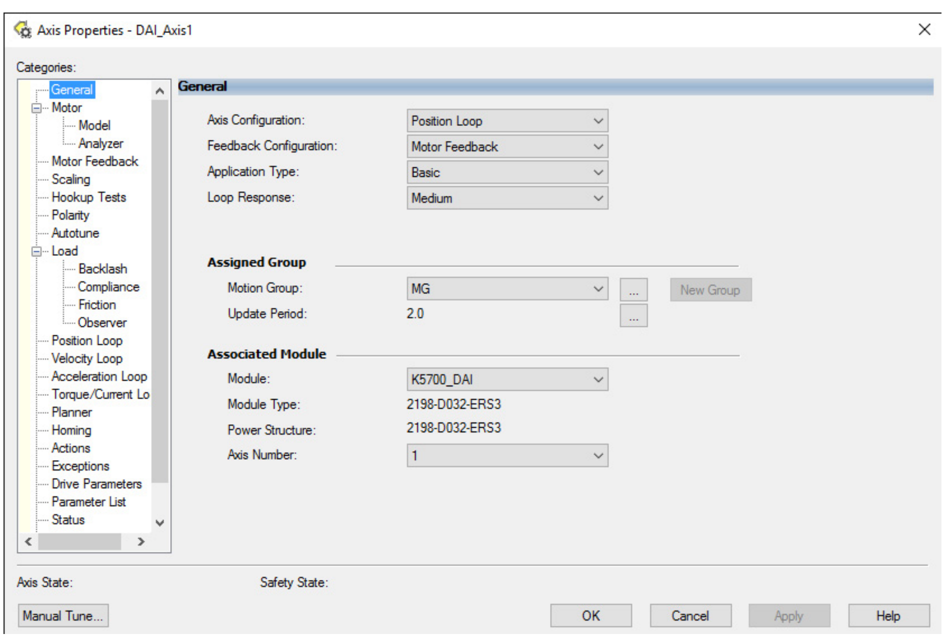
3. Once you are satisfied with the performance, stop motion and disable the drive by repeating step 6 and step 7 on page 43.

## Induction Motor With Encoder Example

In this example, a Kinetix 5700 drive with an induction motor is used in Position Loop mode with a motor-mounted Digital AqB encoder as Motor Feedback.

Follow these steps to enter nameplate data for an induction motor with a motor-mounted Digital AqB encoder.

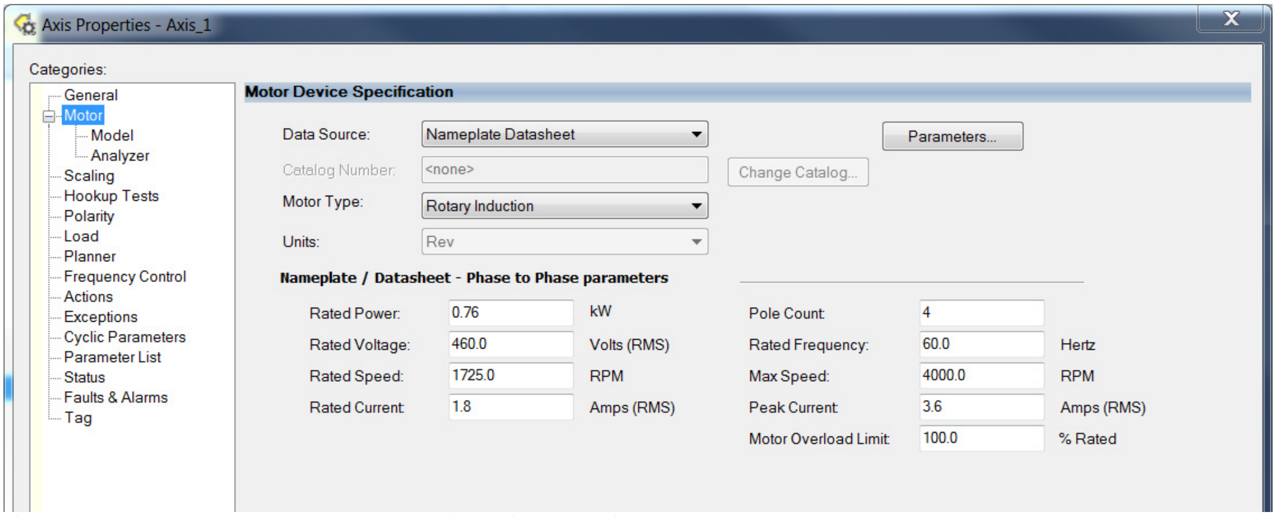
1. In the Controller Organizer, right-click an axis and choose Properties.
2. Select the General category.



a. From the Axis Configuration dropdown menu, choose Position Loop.

b. Click Apply.

3. Select the Motor category.




In this example, a Marathon 56T17F5323J rotary induction motor is used.

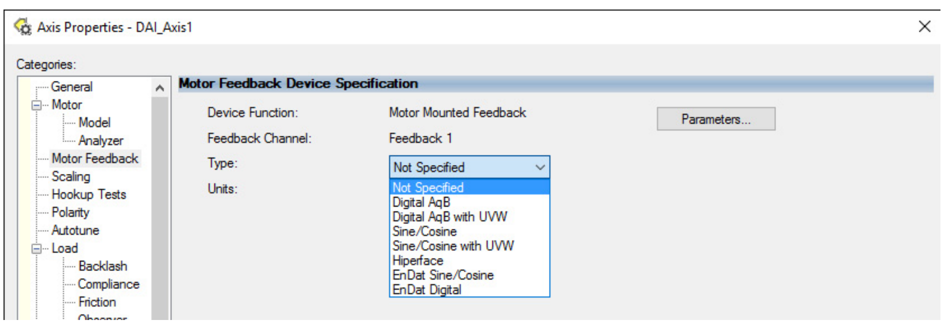
a. From the Data Source dropdown menu, choose Nameplate Datasheet.

b. From the Motor Type dropdown menu, choose Rotary Induction.

c. Enter the Phase to Phase motor data from the motor nameplate or use the manufacturer's equivalent circuit diagram or performance sheet.

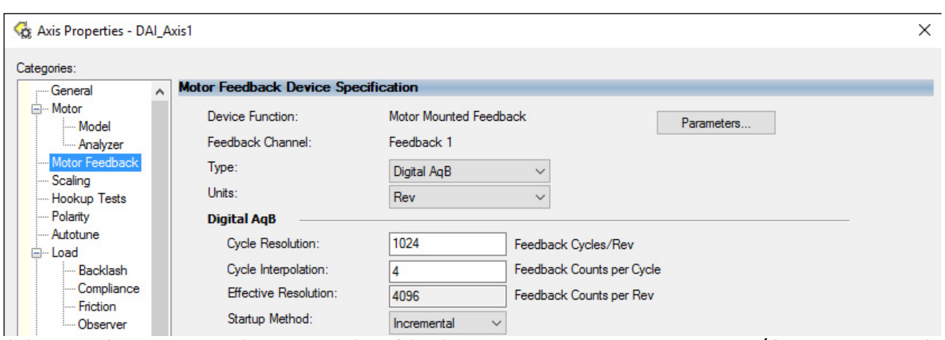
d. Click Apply.

4. Select the Motor Feedback category.




There are multiple feedback types to choose from when Module Properties > Associated Axes > Motor Feedback Device is set to Universal Feedback Port for the axis involved.

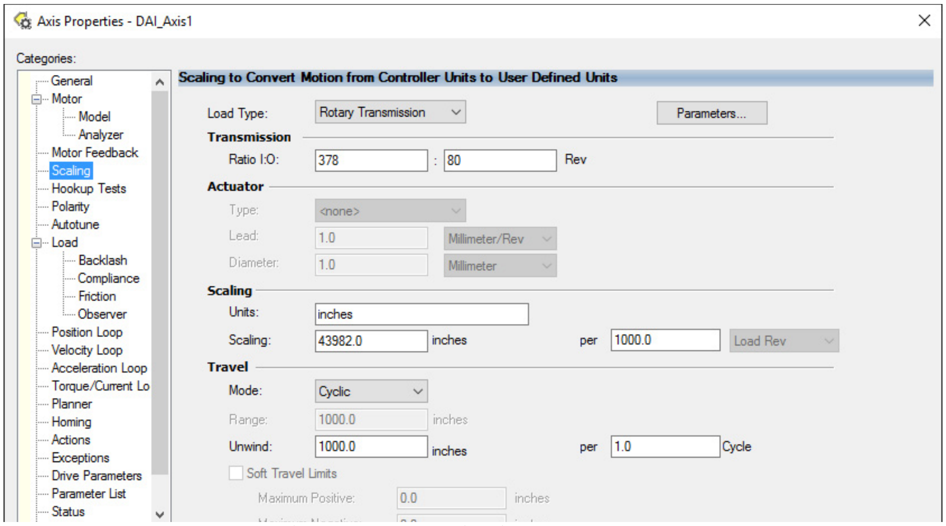
a. From the Type dropdown menu, choose Digital AqB.



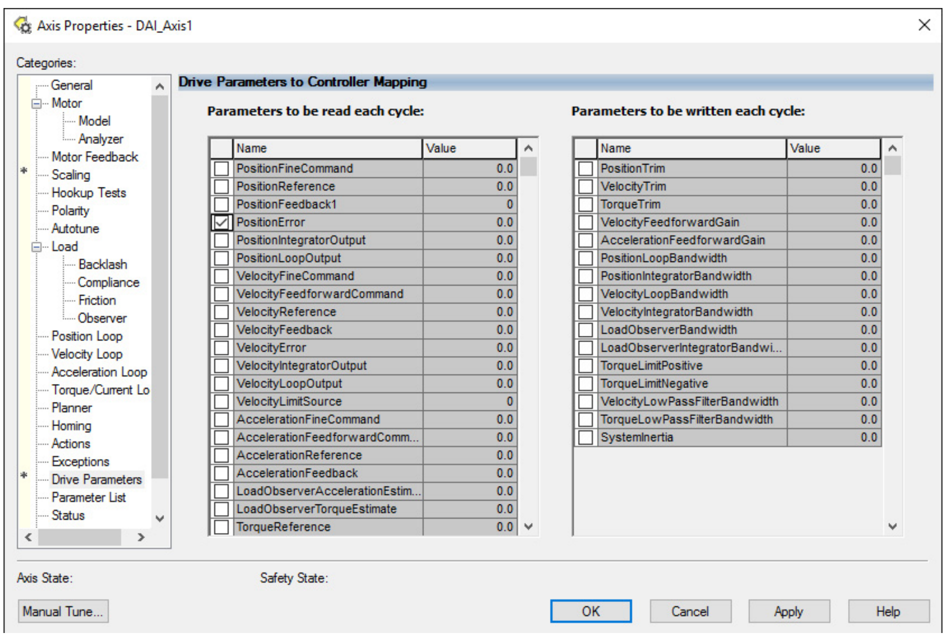

Our Digital AqB is a TTL type feedback with 1024 lines that use quadrature output (Cycle Interpolation = 4). This means that the effective pulses/motor rotation is 4096. The Startup Method is Incremental and not absolute since this AqB encoder type does not have absolute capability.

b. Click Apply.

5. Select the Scaling category.
   Scaling is used to define the Application Units and Motor rotation.




   a. Edit the default values as appropriate for your application.
   b. Click Apply.
6. Select the Drive Parameters category.




7. From the “Parameters to be read each cycle:” scroll menu, check the PositionError and CurrentFeedback parameters.
8. Go online with the controller and download the program.

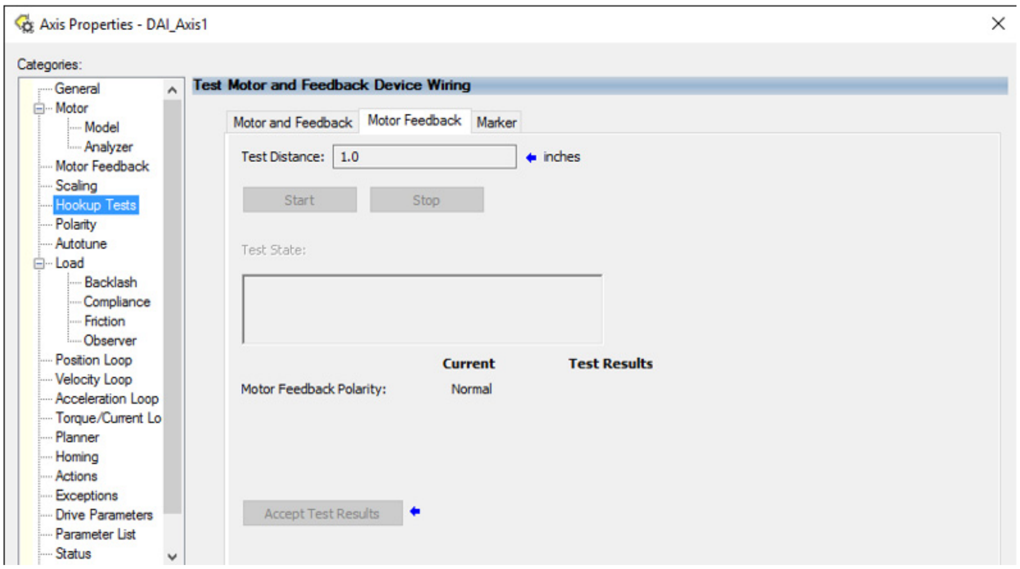
## Axis Properties - Online Tasks

In this section, you use the Hookup Tests category and Motor > Analyzer performance tests, the Autotune category test, and Motion Direct Commands to estimate missing motor specification values.

| | |
|---|---|
| **IMPORTANT** | Rotary Induction motors do not use the Motor and Feedback test. This test fails if used with a rotary induction motor. Do not use this test with a rotary induction motor. |

*Run Hookup Test*

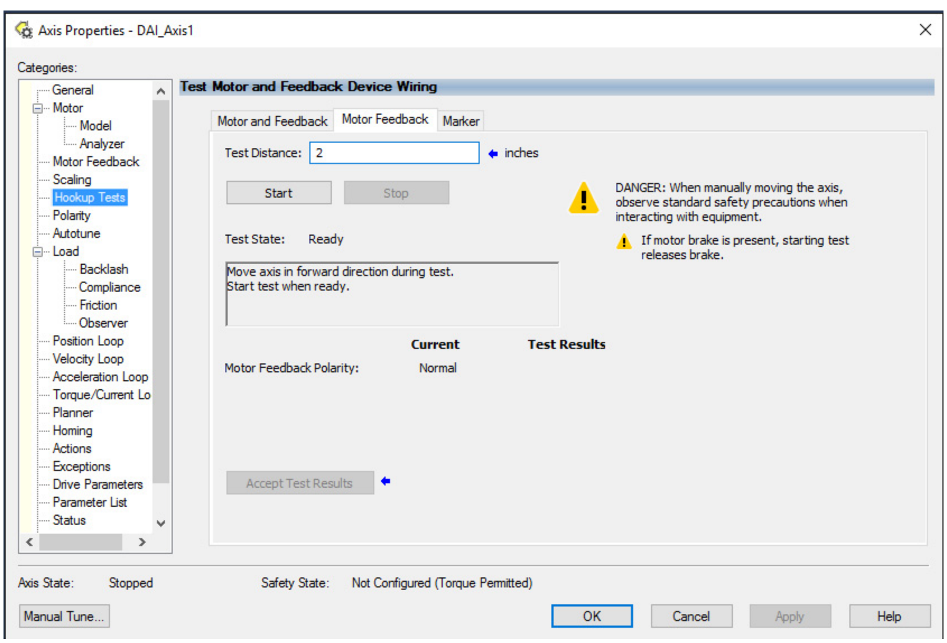
1. Select the Hookup Tests category.



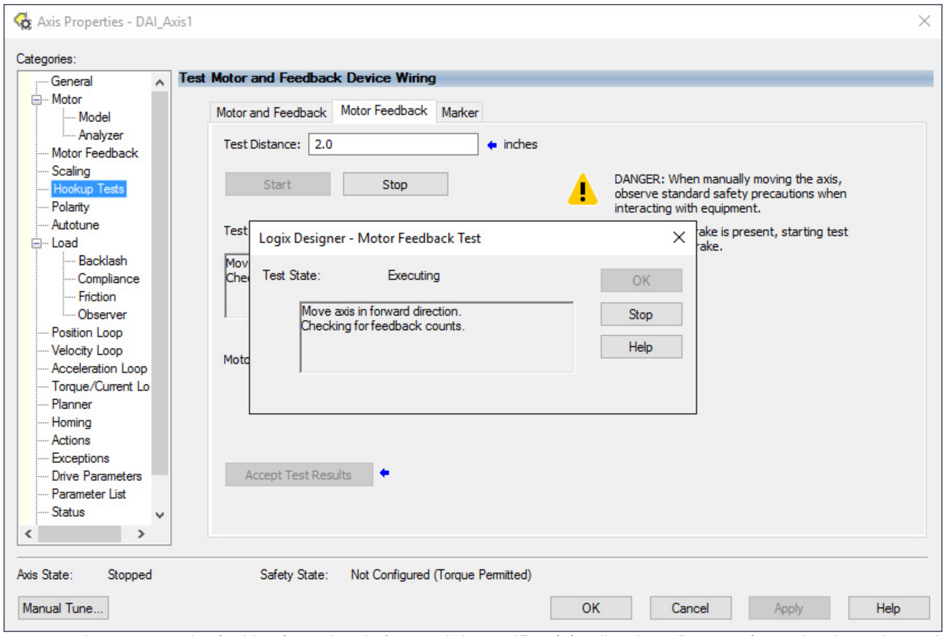
| | |
|---|---|
| **IMPORTANT** | We recommend that you disconnect the load from the motor for the Hookup Tests. |

a. Click the Motor Feedback tab.

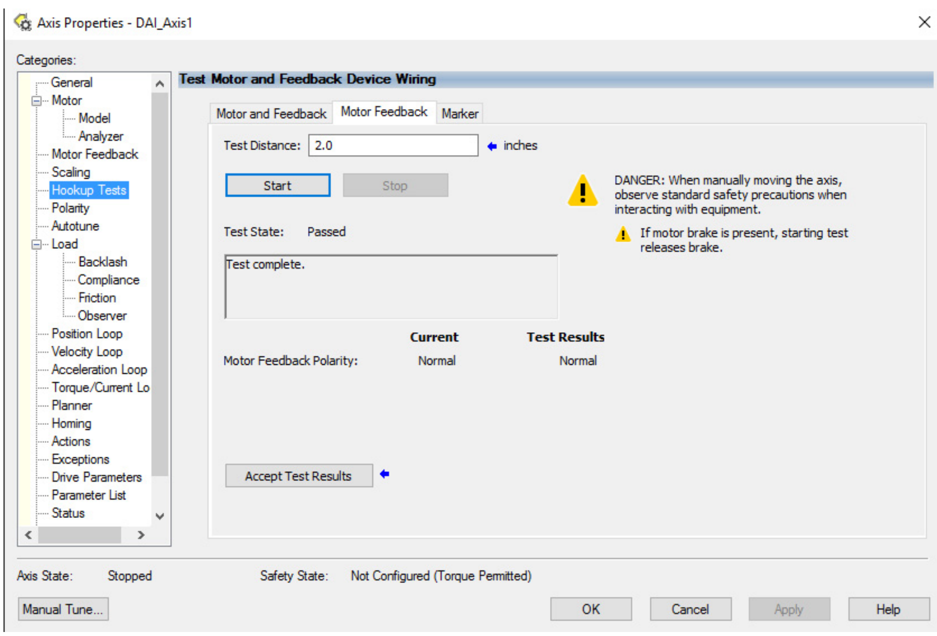
b. Enter a value in the Test Distance field (2.0, for example). You will manually rotate the motor shaft, so make sure that the value you enter is reasonable and not too large. The test completes once the test distance is achieved.



2. Click Start.




a. Manually rotate the motor shaft. Monitor the Axis tag ".ActualPosition" value. Determine whether the value is increasing or decreasing and if that matches the direction you are rotating the motor.

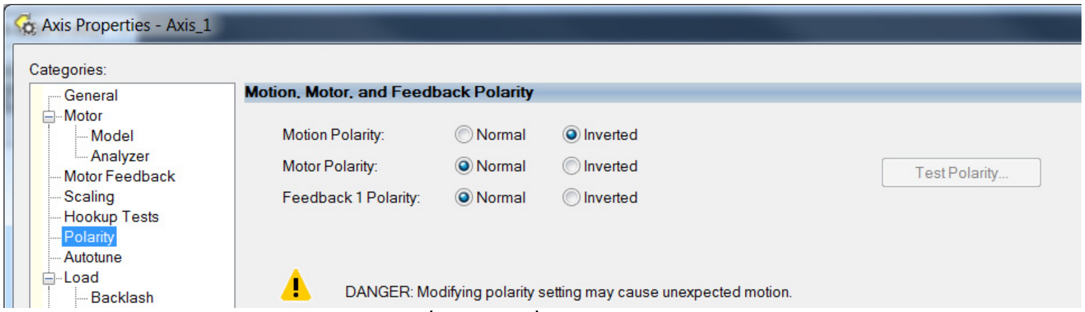



b. If the test was successful, take note of the polarity and click Accept Test Results.

If the test does not complete or an unacceptable machine performance is observed, see Motor Feedback Test on page 71 for suggestions on next steps.

| | |
|---|---|
| **IMPORTANT** | If the test was not successful, troubleshoot the feedback wiring and shielding. When you are using a rotary induction motor, do not use the Motor and Feedback test. This test is not available with a rotary induction motor. |

c. If the motor polarity during operation must be opposite of the observed direction, select the Polarity category.




In this example, when the motor was rotated CW (Clockwise) the ActualPosition value decreased. The application in this example requires the ActualPosition value to increase with CW rotation. So for Motion Polarity, Inverted is selected (Normal was the default).

d. Click Apply.

### *Run Motor > Analyzer Performance Tests*

1. Select the Motor > Analyzer category.

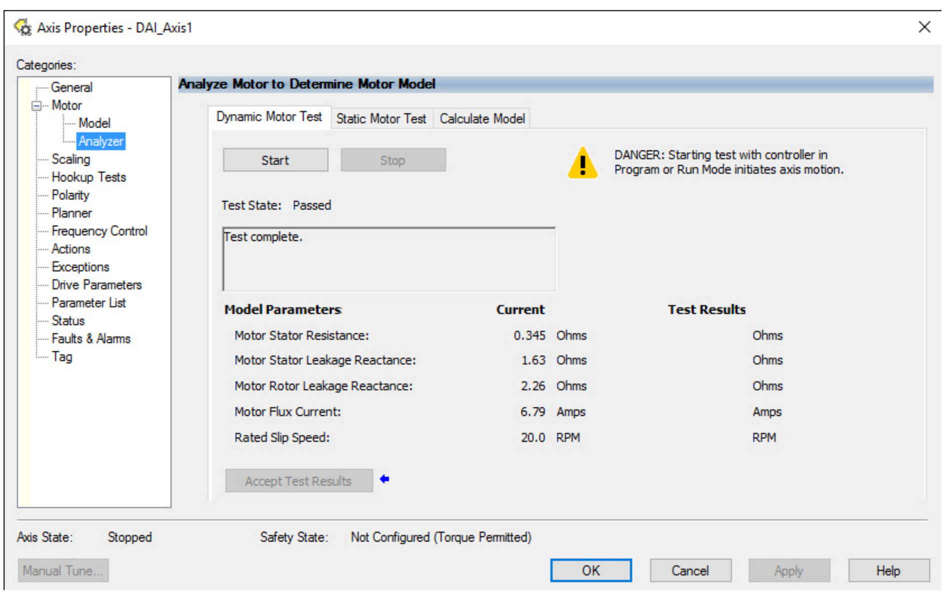
   a. Run the Calculate Model followed by the Static Motor Test (in that order).

| | |
|---|---|
| **IMPORTANT** | You must accept the Motor > Analyzer test results to save the motor model in your axis properties. |

   b. Run the Motor > Analyzer tests as described beginning on page 42.

   Based on the Motor Tests and Autotune Matrix table on page 20, for a closed-loop induction motor, first run Calculate Model, as instructed based on the Logix Designer application version.

   c. If the motor cannot be rotated or cannot be disconnected from the load, use the Static Motor Test. If the motor can be disconnected from the load, use the Dynamic Motor Test.




In this example, the motor is disconnected from the load, so the Dynamic Motor Test was executed. The Dynamic Motor Test is preferred, because the model parameters are measured and not just calculated.

| | |
|---|---|
| **IMPORTANT** | Because the Dynamic Motor Test rotates the motor several times with increasing speed, and travel limits are not observed, you must disconnect the load from the motor for this test. |

2. Click Start.
   a. If the test completes, click Accept Test Results.

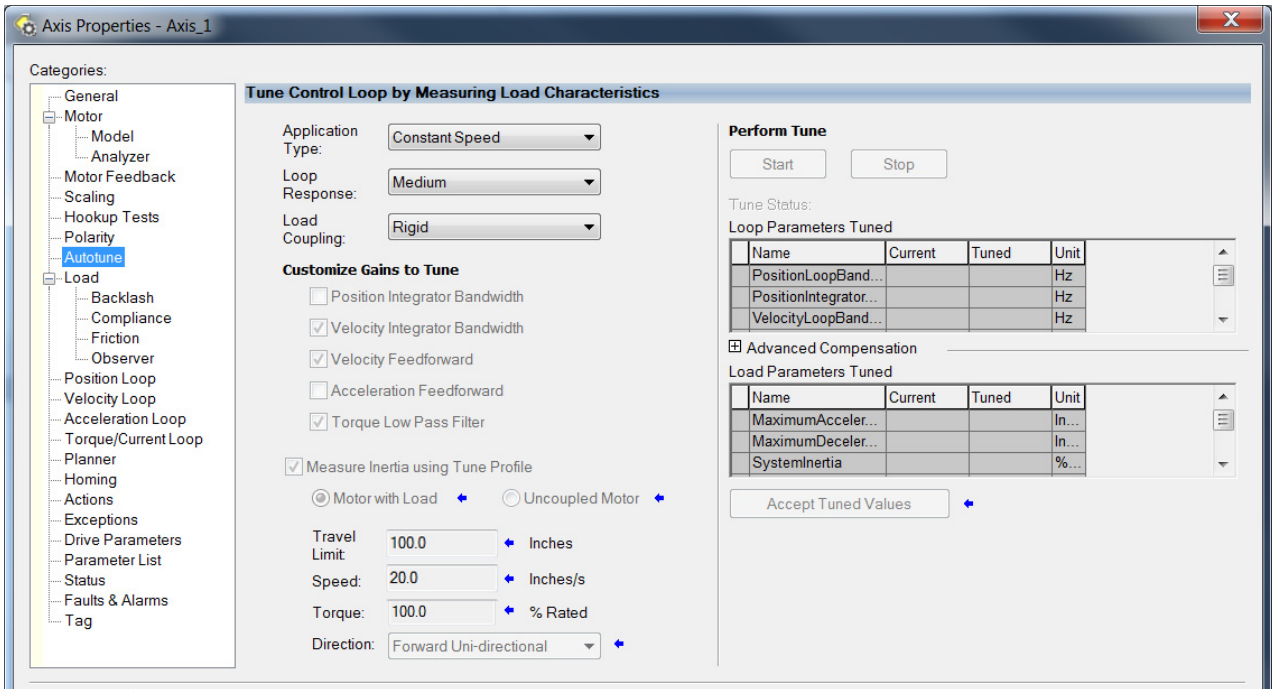
| | |
|---|---|
| **IMPORTANT** | If using Studio 5000 Logix Designer, version 28 or earlier, enter a Motor Inertia value in the Load category so that the Dynamic Motor Test completes. |

If the test does not complete or an unacceptable machine performance is observed, see Dynamic Motor Test on page 71 for suggestions on next steps. Depending on the motor properties, you may want to execute the Dynamic Motor Test a few times to be sure that the results of each execution of the test are similar.

   b. Click Apply and reconnect the load to the motor.

*Run Autotune*

1. Select the Autotune category.




   a. From the Application Type dropdown menu, choose Constant Speed.

      Keep the default settings of Medium (Loop Response) and Rigid (Load Coupling) for most applications as a start in the application setup.

      If Autotune doesn't provide satisfactory results, see the Motion System Tuning Application Technique, publication MOTION-AT005, for help with using different tuning techniques.

   b. Make sure that the Measure Inertia using Tune Profile checkbox is checked.

| | |
|---|---|
| **IMPORTANT** | Checking the Measure Inertia Using Tune Profile checkbox rotates the motor. If your load is coupled, see the Motion System Tuning Application Technique, publication MOTION-AT005, for additional information on the Autotune test, or make sure that the Measure Inertia Using Tune Profile checkbox is not checked. |

   c. Make sure that the Motor with Load radio button is selected.
   d. Enter the longest available tuning distance Travel Limit value that can be used.
   e. Enter approximately 50...75% of the Planner category maximum velocity for the Speed value.
   f. Verify that the Torque value is 100% unless there is a requirement that such motor torque could affect machine mechanics.
   g. From the Direction drop down menu, select the direction of the Autotune.
      This is especially important if your load is uni-directional.

2. Click Start.
   a. If the test completes, then from the Autotune window, click Accept Tuned Values.

      When you click Accept Tuned Values, the Tuned values become the Current values in the Load and Loop Parameter Tuned tables.

      If the test does not complete or an unacceptable machine performance is observed, see Autotune Test on page 72 for suggestions on next steps.
   b. By using Motion Direct Commands, accelerate and decelerate the motor at different speeds and positions to verify performance.

      If the test does not complete or unacceptable machine performance is observed, see Autotune Test on page 72 for suggestions on next steps.
   c. Click Apply.

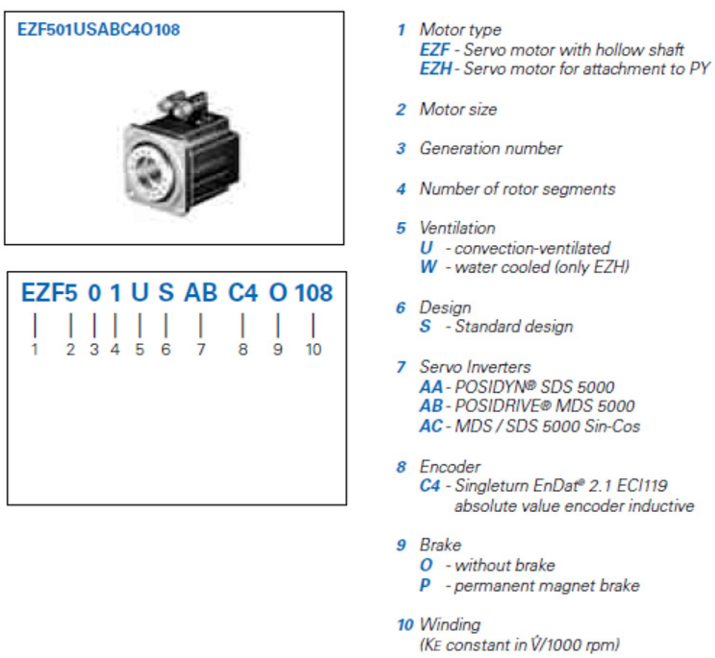
      The Autotune Test outputs a step impulse to the motor. If the load cannot respond to this quick input (that is, this application has a low bandwidth or large inertia), disconnect the load and execute the Autotune Test with only the motor. By executing the test in this way, you will, at a minimum, have a similar characterization of the Kinetix motor catalog number. The application settings are applied and the Load Ratio is estimated. Deeper tuning than this is outside the scope of this document. You can see the Motion System Tuning Application Technique, publication MOTION-AT005, for additional guidance.

## Rotary Surface Permanent-magnet Motor Example

Observe the guidelines on page 4 for implementing nameplate datasheet entry for rotary permanent-magnet motors. The Kinetix 5300 and Kinetix 5700 drive systems uses the Studio 5000 Logix Designer application to configure the program.

In this example, a Stober through-shaft motor is required for a specific application requirement that lets material move through the motor shaft while rotating.

For this application, the Stober EZF505USFTC80141 motor was used.



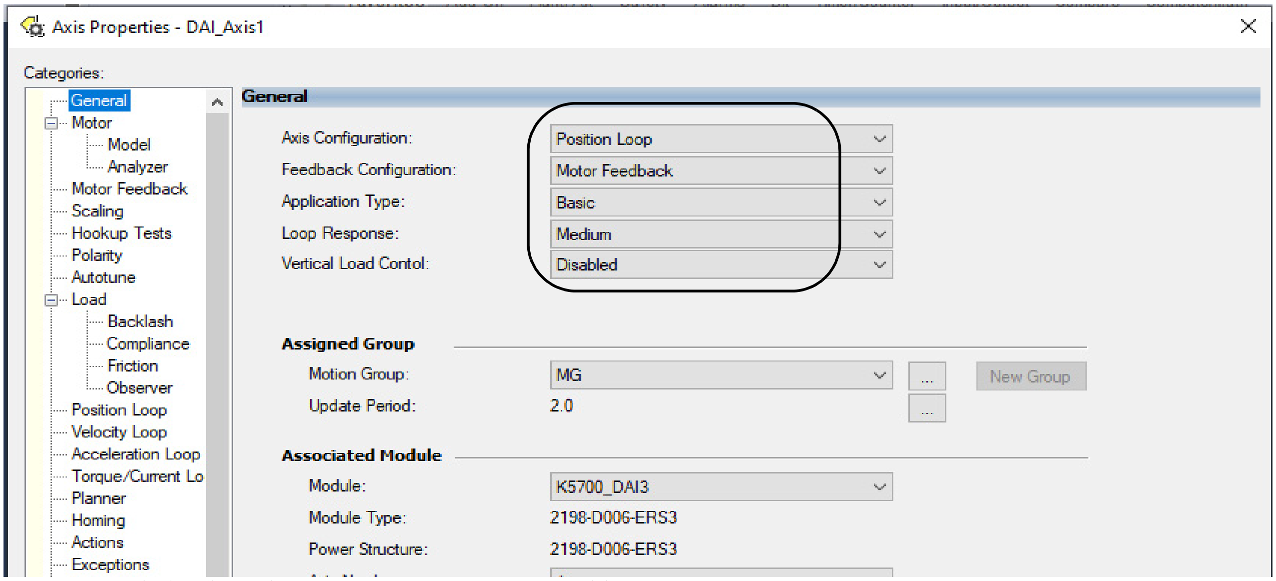

This motor includes an ECI119 Heidenhain EnDat encoder, which is a supported feedback type on Kinetix 5700 servo drives. This encoder is a 2048 sine/cosine cycles-per-revolution and single-turn absolute retention encoder. For more on Kinetix 5300 and Kinetix 5700 feedback compatibility, see Table 2 on page 5 or the following publications:

- Kinetix 5300 Single-axis EtherNet/IP Servo Drives User Manual, publication 2198-UM005
- Kinetix 5700 Servo Drives User Manual, publication 2198-UM002

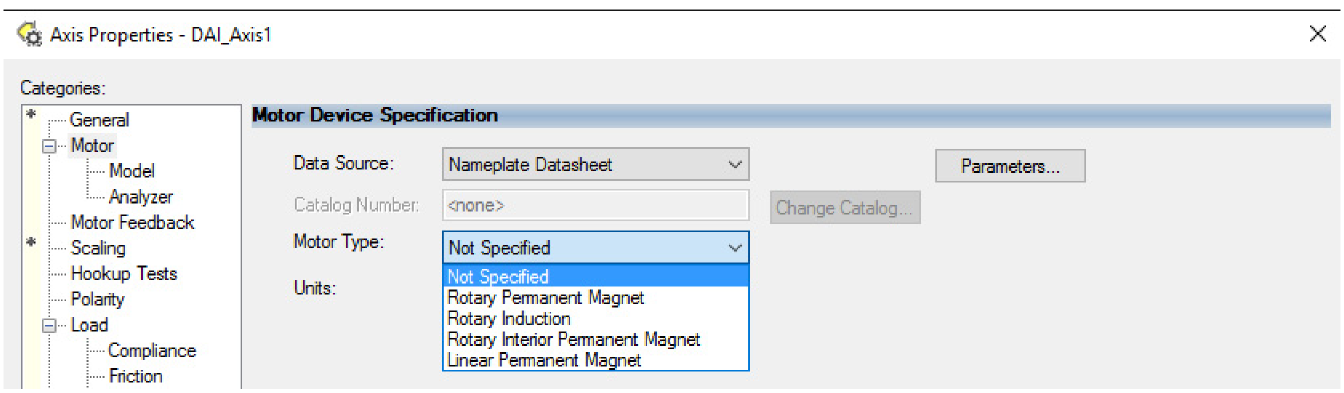
In your Studio 5000 Logix Designer application, while in offline mode, configure this motor and Kinetix 5700 drive. Assign the axis in the motion group to the Kinetix 5700 drive that you created in the I/O Configuration folder.

Follow these steps to enter the nameplate data for a rotary surface permanent-magnet motor.

1. In the Controller Organizer, right-click an axis and choose Properties.
2. Select the General category.

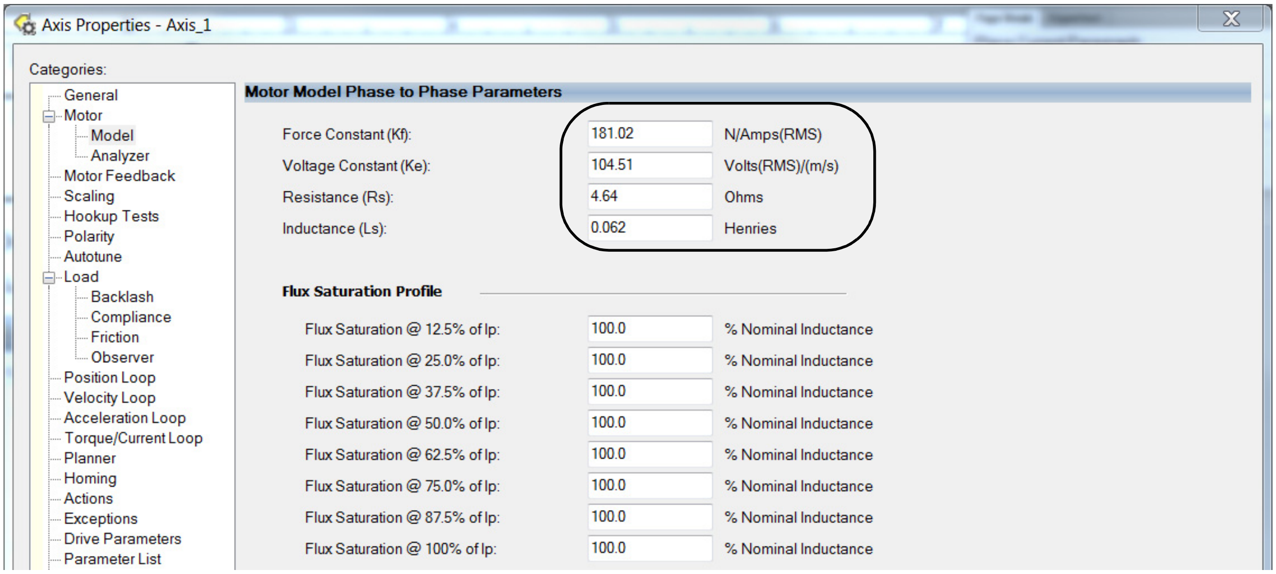



   a. From the Axis Configuration dropdown menu, choose Position Loop.
   b. Verify that the other General attributes are configured as shown in this example.
   c. Click Apply.
3. Select the Motor category.




   a. From the Data Source dropdown menu, choose Nameplate Datasheet.
   b. From the Motor Type dropdown menu, choose Rotary Permanent Magnet.
   c. Enter motor data from the motor nameplate or use the manufacturer’s equivalent circuit diagram or performance sheet.
   d. Click Apply.

4. Select the Motor > Model category.

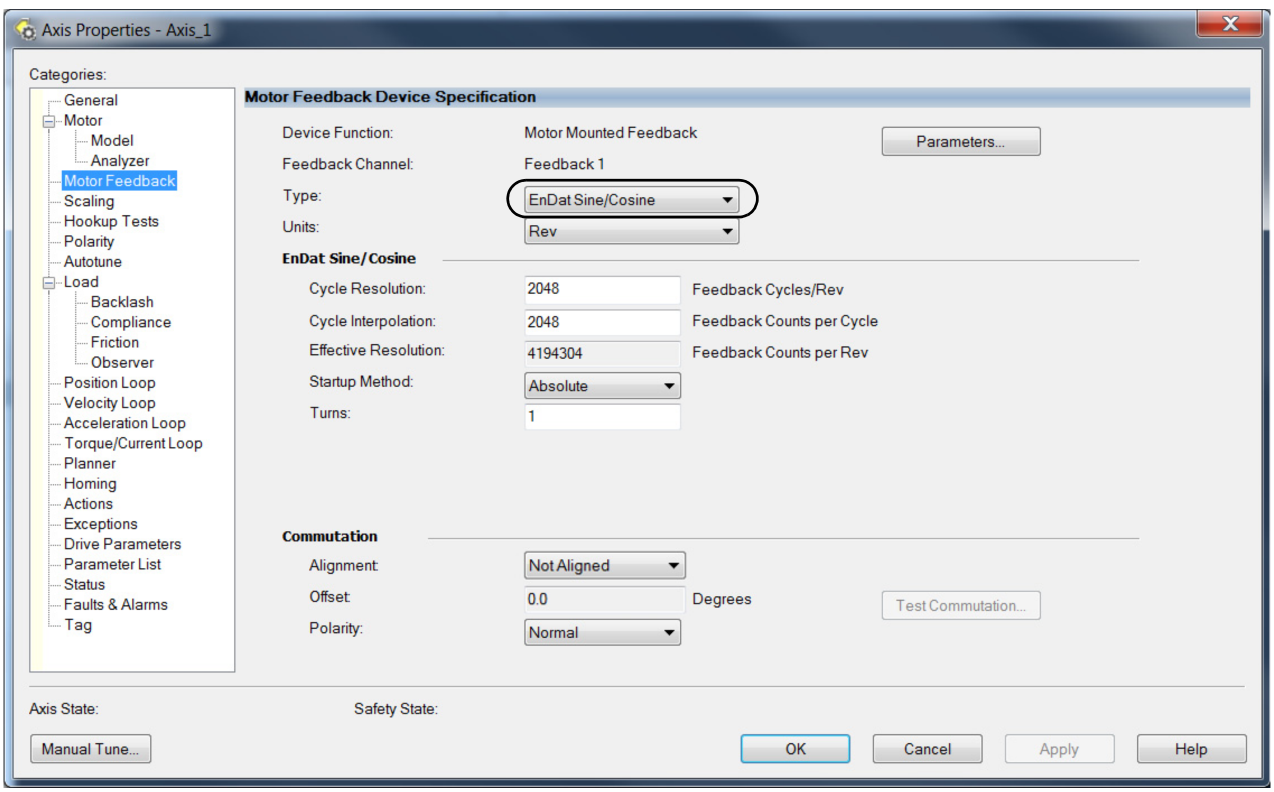



a. Enter motor model phase-to-phase parameters.

| IMPORTANT | Unlike the rotary induction motor, more data in the model is required for proper motor control. See Permanent-magnet Motor Model Attribute Definitions on page 19 for more information on the motor-model information requirements. |
|---|---|

b. Click Apply.

5. Select the Motor Feedback category.

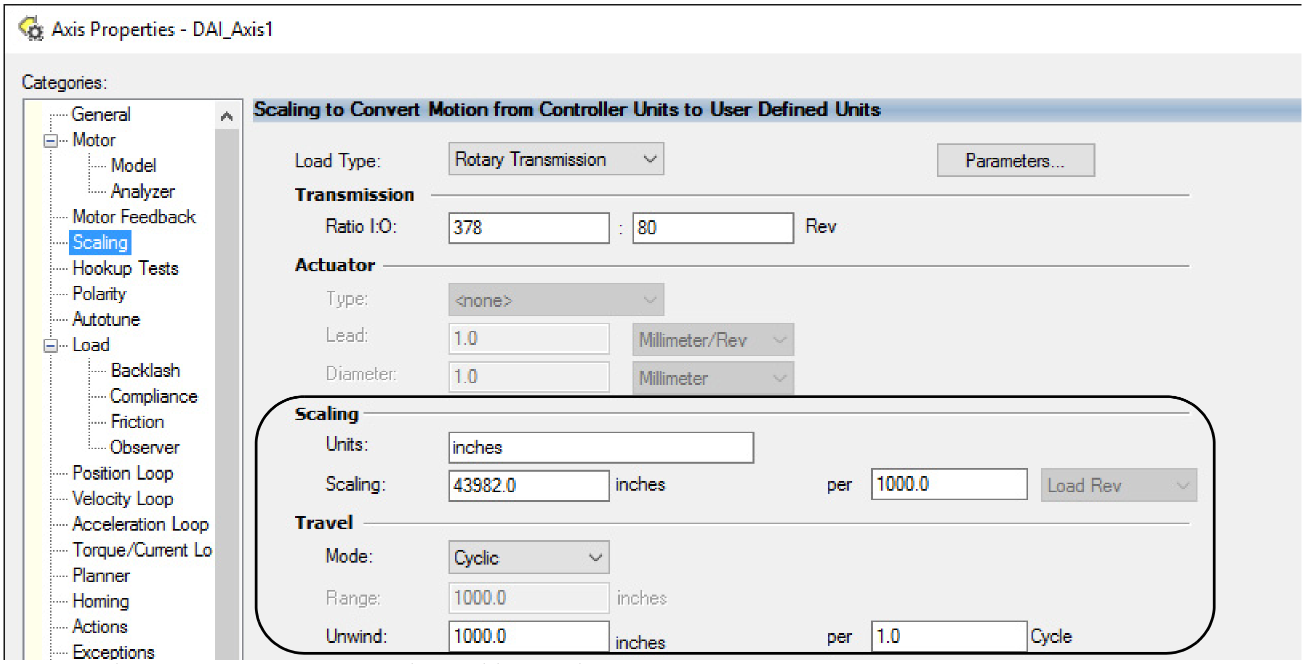



a. From the Type dropdown menu, choose EnDat Sine/Cosine.

b. Enter the Heidenhain encoder data, here known as EnDat Sine/Cosine, the cycle resolution, and number of turns.

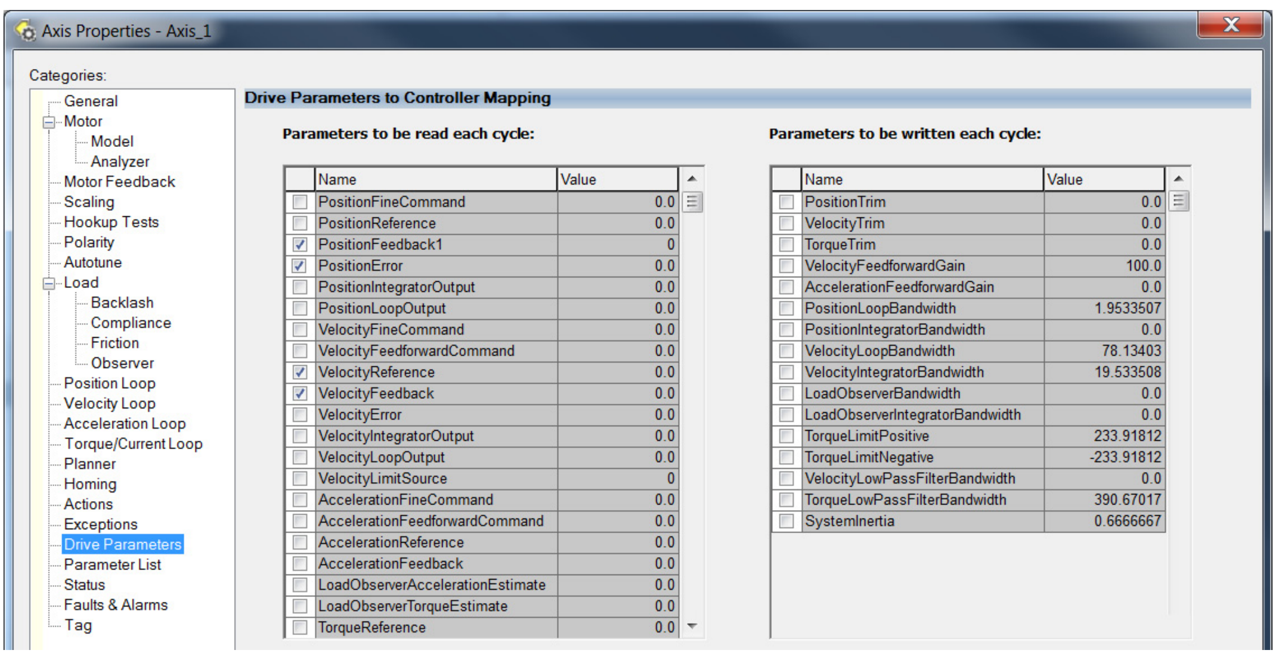
c. Click Apply.

6. Select the Scaling category.




7. Enter the scaling values based on the machine position requirement.
   a. In this application, 1.0 load revolution equals 1.0 motor revolution.
   b. From the Mode dropdown menu, choose Cyclic.

      Travel mode was set to Cyclic and 1 load revolution to unwind each cycle. The cyclic choice allows for an application-defined unwind. This means that when the position approaches the unwind value and zero, it increases until it reaches the unwind value, then it rolls over to zero and repeats.
   c. Click Apply.
8. Select the Drive Parameters category.




   a. Check the parameters that you want to monitor for performance evaluation.

      In a position loop configuration, normally PositionFeedback1, PositionError, VelocityReference, VelocityFeedback, and CurrentFeedback give a good indication of performance.
   b. Click Apply.
9. Go online with the controller and download the program.

## Axis Properties - Online Tasks

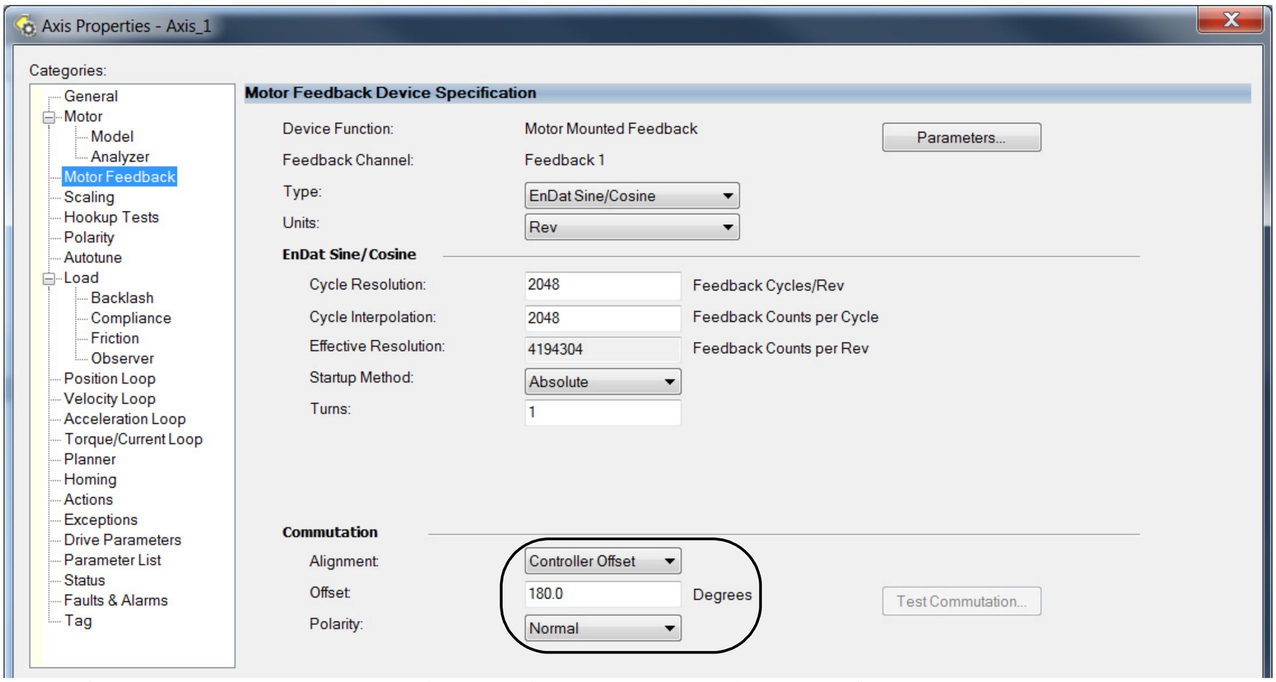
At this point, the drive has main power applied but is not energized (enabled). In this section, you choose the motor type you are using, and then perform the Commutation, Hookup, and Autotune Tests.

When the project is downloaded and online with the controller, the CIPAxisState status is typically Commutation Not Configured.

*Configure Commutation Attributes*

Follow these steps to configure Motor Feedback > Commutation when the Offset value is known by the manufacturer.

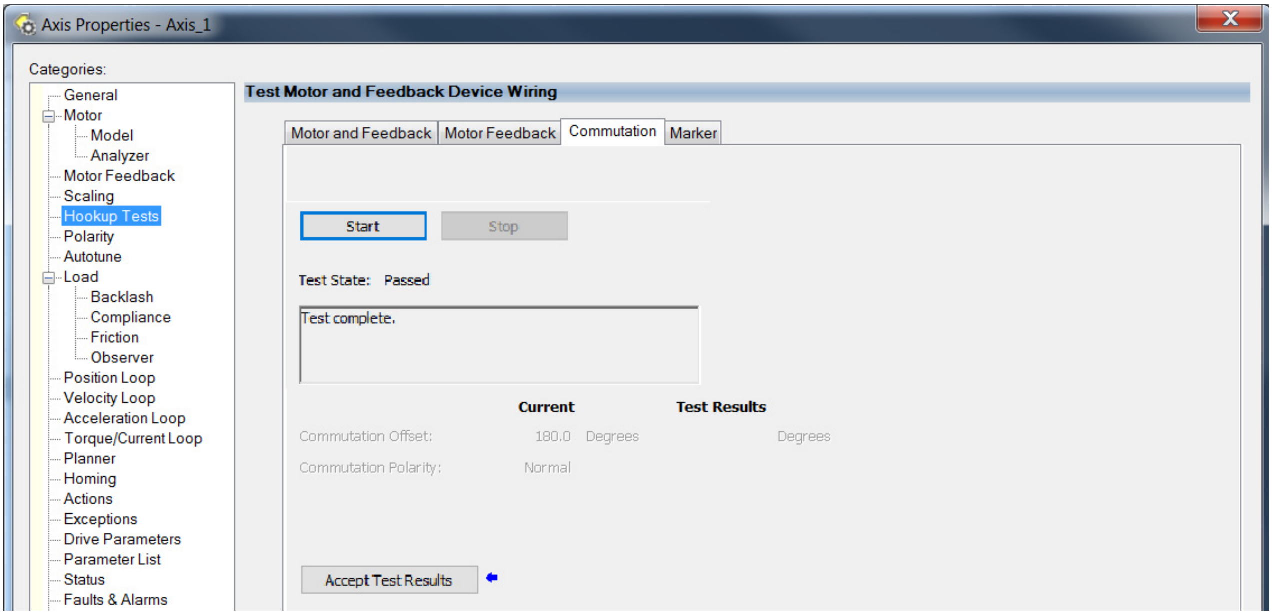
1. Select the Motor Feedback category.




2. From the Alignment dropdown menu, choose Controller Offset and enter the Offset value in degrees.
   In this example, the Controller Offset is 180 degrees.
3. Click Apply.
   If the Controller Offset is not known by the manufacturer, use the Hookup Tests category, Commutation Test tab to calculate and populate the commutation attributes.

Follow these steps to perform the Commutation test when the Motor Offset is not known by the manufacturer.

1. Select the Hookup Tests category.

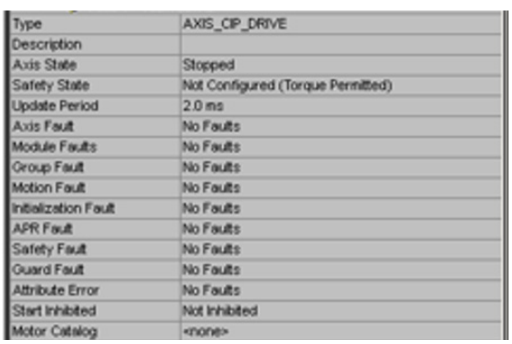



| **IMPORTANT** | Before you begin the Commutation Test, be sure to disconnect the motor from the load, including transmissions of any sort (for example, gearbox or coupling). |
|---|---|

2. Click the Commutation tab.
3. Click Start.
4. Click Accept Test Results, if the test completes.

   If the Commutation test fails, see Commutation Test on page 72 for suggestions on next steps if the test does not complete.

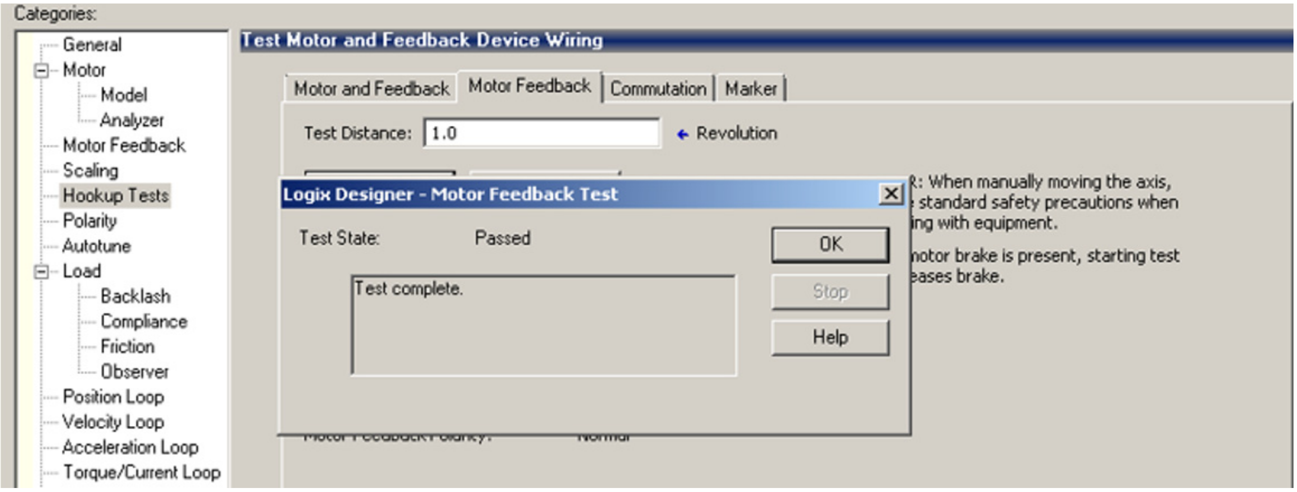
   In the Controller Organizer, Axis Quick View, the axis is in the Stopped State.



| | |
|---|---|
| Type | AXIS_CIP_DRIVE |
| Description | |
| Axis State | Stopped |
| Safety State | Not Configured (Torque Permitted) |
| Update Period | 2.0 ms |
| Axis Fault | No Faults |
| Module Faults | No Faults |
| Group Fault | No Faults |
| Motion Fault | No Faults |
| Initialization Fault | No Faults |
| APR Fault | No Faults |
| Safety Fault | No Faults |
| Guard Fault | No Faults |
| Attribute Error | No Faults |
| Start Inhibited | Not Inhibited |
| Motor Catalog | <none> |

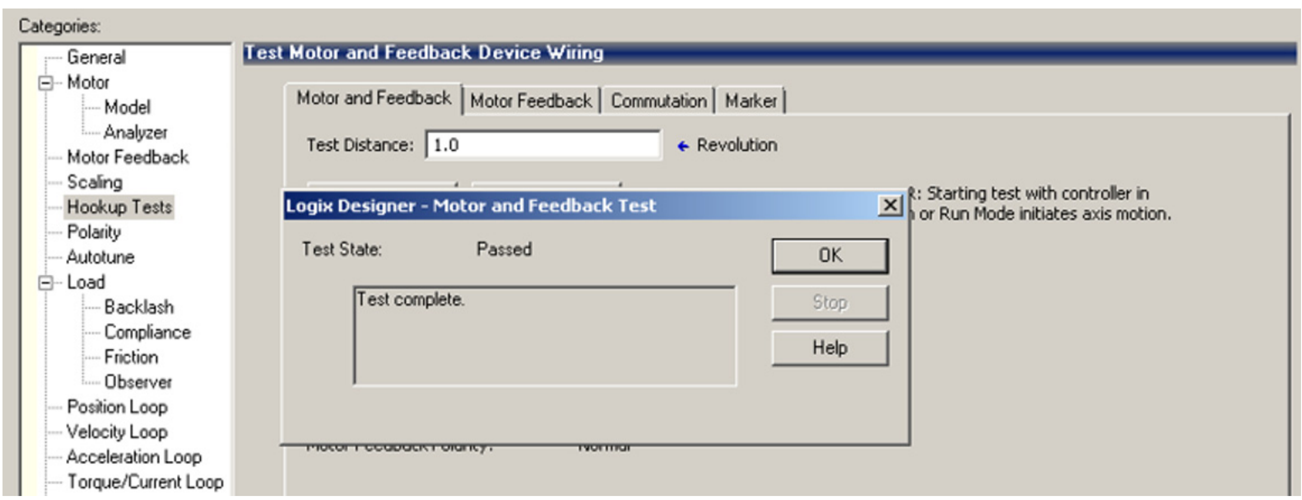
### *Run Hookup Tests*

1. Select the Hookup Tests category.




2. Click the Motor Feedback tab.
   a. Enter 1 load revolution (as seen in Scaling) in the Test Distance field and click Start.
   b. Move the motor by hand, 1 load revolution.
   c. Click OK and Accept Test Results.

      If the Motor Feedback test fails, see Motor Feedback Test on page 71 for suggestions on next steps.
   d. Click Apply.
3. Click the Motor and Feedback tab.
   a. Enter 1 load revolution (as seen in Scaling) in the Test Distance field and click Start.




   b. Click OK.

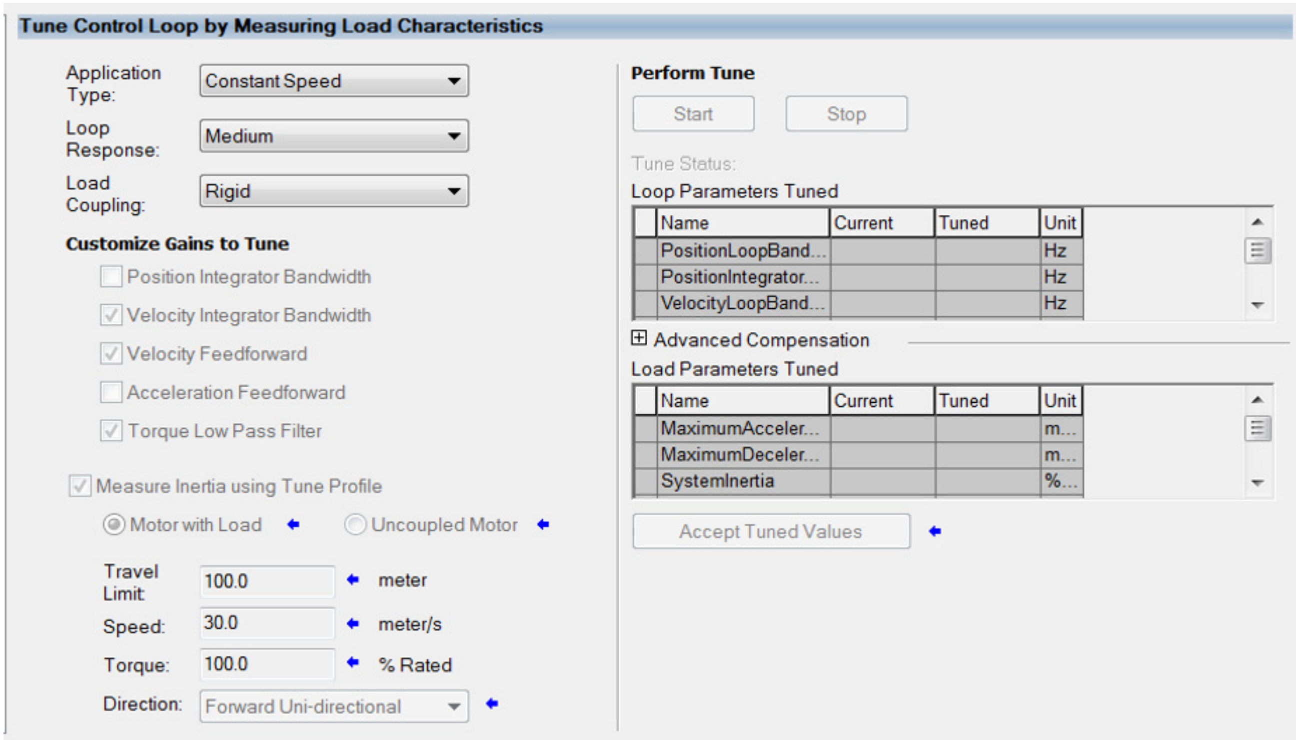
      Studio 5000 Logix Designer application asks if the axis rotation was in the positive direction. Based on the machine requirement, choose as follows: If the axis moved in the positive direction, select yes. If the axis moved in the negative direction, select no.
   c. Accept Test Results.

| | |
|---|---|
| **IMPORTANT** | The Motor and Feedback Test is required to be run once unless the drive or actuator is replaced. If such a replacement occurs, it may be possible that the test results remain valid. If you don't know if the test results remain valid after the replacement, the test must be repeated. |

      If the Motor and Feedback test fails, see Motor and Feedback Test on page 71 for suggestions on next steps.
   d. Click Apply.

*Run Autotune*

1. Select the Autotune category.




2. If necessary, disconnect the load from the motor.

   The Autotune Test outputs a step impulse to the motor. If the load cannot respond to this quick input (that is, this application has a low bandwidth or large inertia), disconnect the load before the Autotune test is executed.

   If you execute the Autotune Test in this way (with only the motor), you will, at a minimum, have a similar characterization of the Kinetix motor catalog number. The application settings are applied and the Load Ratio is estimated. Deeper tuning than this is outside the scope of this document. You can see the Motion System Tuning Application Technique, publication MOTION-AT005, for additional guidance.

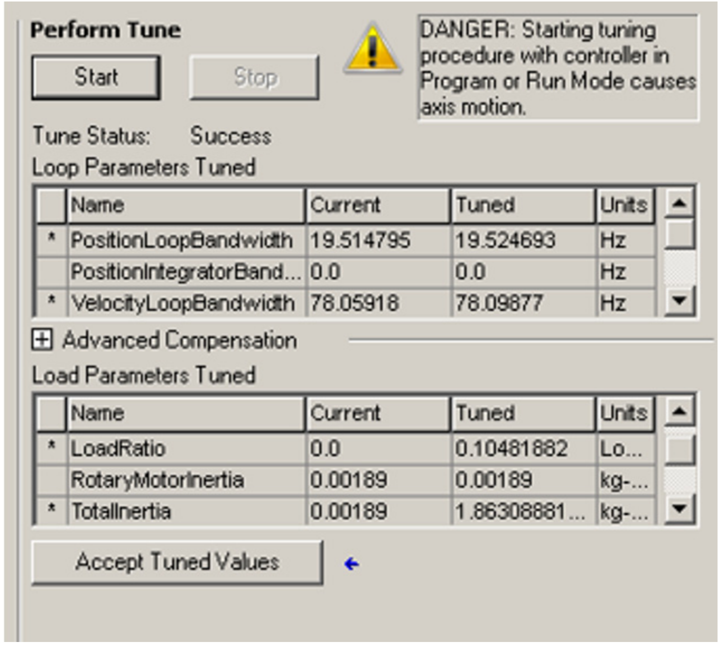
3. Configure the application type, loop response, and load coupling to what the machine application requires.

| | |
|---|---|
| **IMPORTANT** | See Motion System Tuning Application Technique, publication MOTION-AT005, to determine the best tuning method for your machine application. |

4. Check Measure Inertia using Tune Profile.

| | |
|---|---|
| **IMPORTANT** | Checking the Measure Inertia using Tune Profile checkbox rotates the motor. If your load is coupled, see the Motion System Tuning Application Technique, publication MOTION-AT005 for additional information on the Autotune Test, or make sure that the Measure Inertia using Tune Profile checkbox is not checked. |

5. Check Motor with Load.
6. In the Travel Limit field, enter as long a travel limit as possible with the machine mechanics.
7. In the Speed field, enter approximately 50…75% of the Planner category maximum velocity.
8. In the Torque field, enter 100% of motor rated torque based on the machine application requirements.
9. Set Direction for rotation in one direction (Uni-directional) or both directions (Bi-directional).
10. Click Start.




If tuning is successful, replace the Current values with the Tuned values by clicking Accept Tuned Values.

If tuning fails, see Autotune Test on page 72 for suggestions on next steps if the test does not complete.

11. By using Motion Direct Commands, enable the drive (MSO), then jog the motor (MAJ). Use different speeds and positions to verify performance.

| | |
|---|---|
| **IMPORTANT** | If the drive has not been enabled before this step (new installation), verify that you have safeguards in place to safely remove power from the drive if there is an unstable situation where the drive can produce undesired motion. |

12. Click Apply.

## Linear Surface Permanent-magnet Motor Example

Observe the guidelines on page 4 for implementing nameplate datasheet entry for linear surface permanent-magnet motors. The Kinetix 5300 and Kinetix 5700 drive system uses the Studio 5000 Logix Designer application to configure the program.

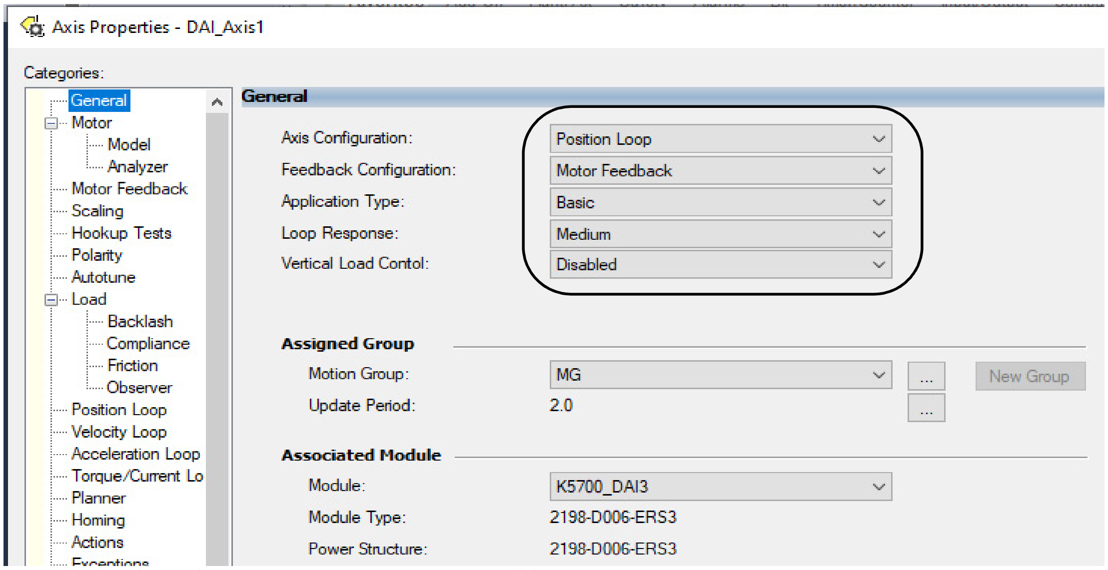
In this example, a 3.18 kW linear thruster, comparable to an Allen-Bradley LDAT-Series linear thruster is used. The linear thruster features an external Digital AqB with UVW encoder for motor feedback. For more on Kinetix drive feedback compatibility, see Table 2 on page 5.

In your Studio 5000 Logix Designer application, offline mode, configure this motor and Kinetix drive. Assign the axis in the motion group to the Kinetix drive that you created in the I/O Configuration folder.

Follow these steps to enter the nameplate data for a linear surface permanent-magnet motor.

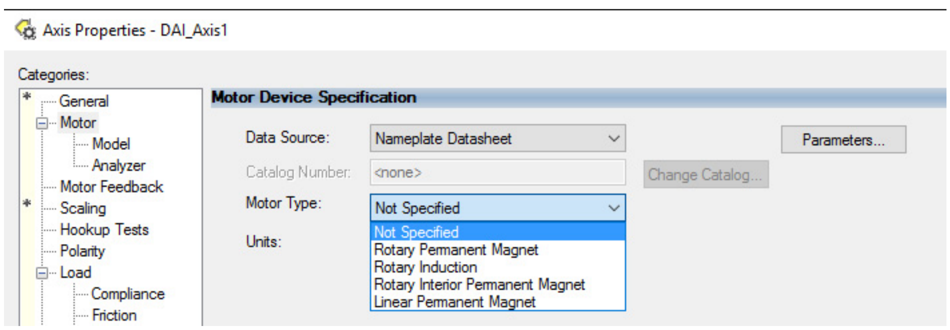
1. In the Controller Organizer, right-click an axis and choose Properties.

2. Select the General category.



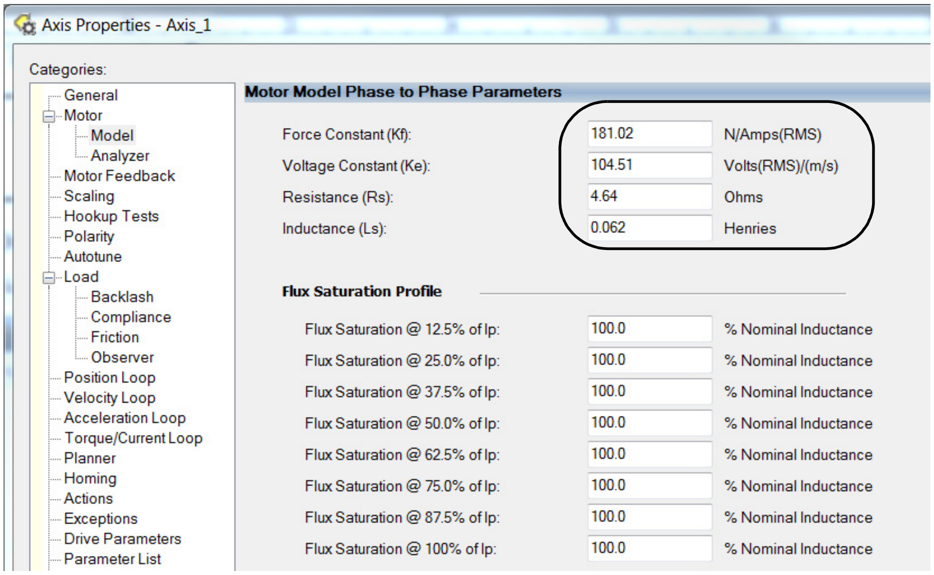

a. From the Axis Configuration dropdown menu, choose Position Loop.
b. Verify that the other General attributes are configured as shown in this example.
c. Click Apply.

3. Select the Motor category.




a. From the Data Source dropdown menu, choose Nameplate Datasheet.
b. From the Motor Type dropdown menu, choose Linear Permanent Magnet.
c. Enter motor data from the motor nameplate or use the manufacturer’s equivalent circuit diagram or performance sheet.
d. Click Apply.

4. Select the Motor > Model category.

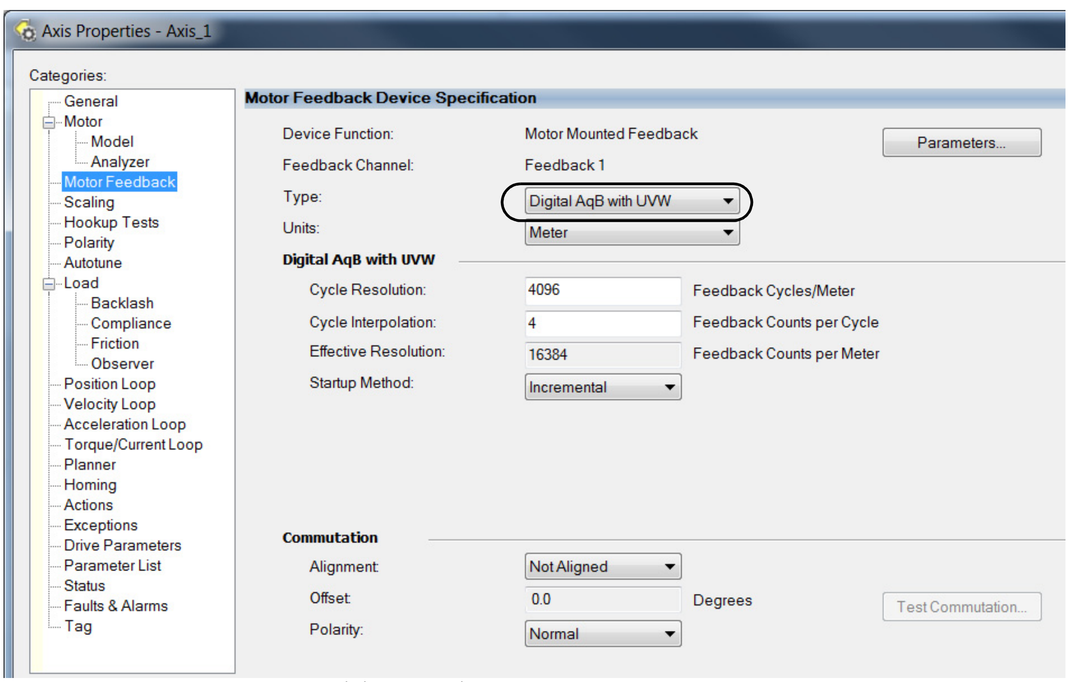



a. Enter motor model phase-to-phase parameters.

| | |
|---|---|
| **IMPORTANT** | Unlike the rotary induction motor, more data in the model is required for proper motor control. See Permanent-magnet Motor Model Attribute Definitions on page 19 for more information on the motor-model information requirements. |

b. Click Apply.

5. Select the Motor Feedback category.

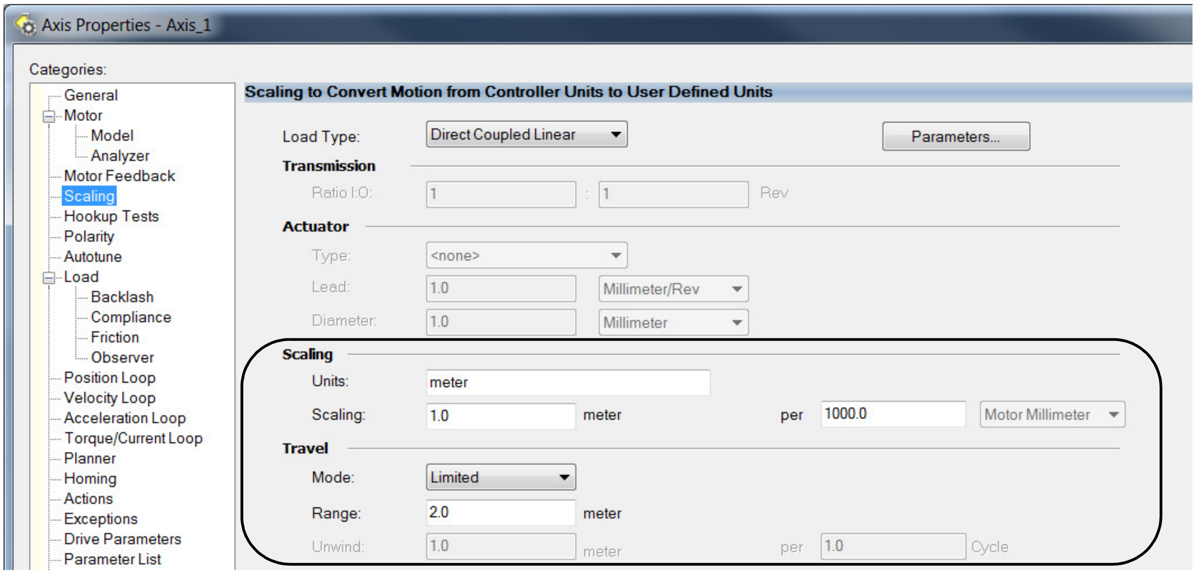



a. From the Type dropdown menu, choose Digital AqB with UVW.

b. In the Cycle Resolution field, enter the value from the motor datasheet.

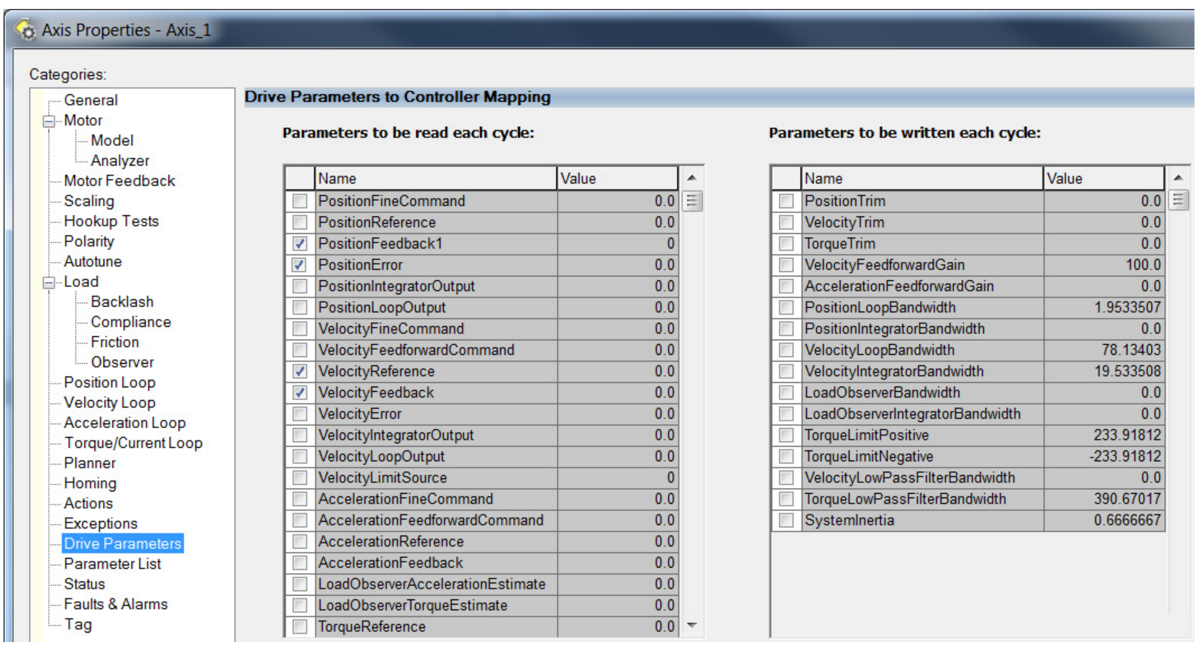
c. Click Apply.

6. Select the Scaling category.




7. Enter the scaling values based on the machine requirements.
   a. In this application, 1.0 meter equals 1000.0 motor millimeters.
   b. From the Mode dropdown menu, choose Limited.

      Travel mode was set to Limited and 2.0 meters.
   c. Click Apply.
8. Select the Drive Parameters category.




   a. Check the parameters that you want to monitor for performance evaluation.

      In a position loop configuration, normally PositionFeedback1, PositionError, VelocityReference, VelocityFeedback, and CurrentFeedback give a good indication of performance.

| | |
|---|---|
| **IMPORTANT** | See the Motion System Tuning Application Technique, publication MOTION-AT005, to determine the best tuning method for your machine application. |

   b. Click Apply.
9. Go online with the controller and download the program.

## Axis Properties - Online Tasks

In this section, you use the Hookup Tests category performance tests, the Autotune category test, and Motion Direct Commands to estimate missing motor specification values.

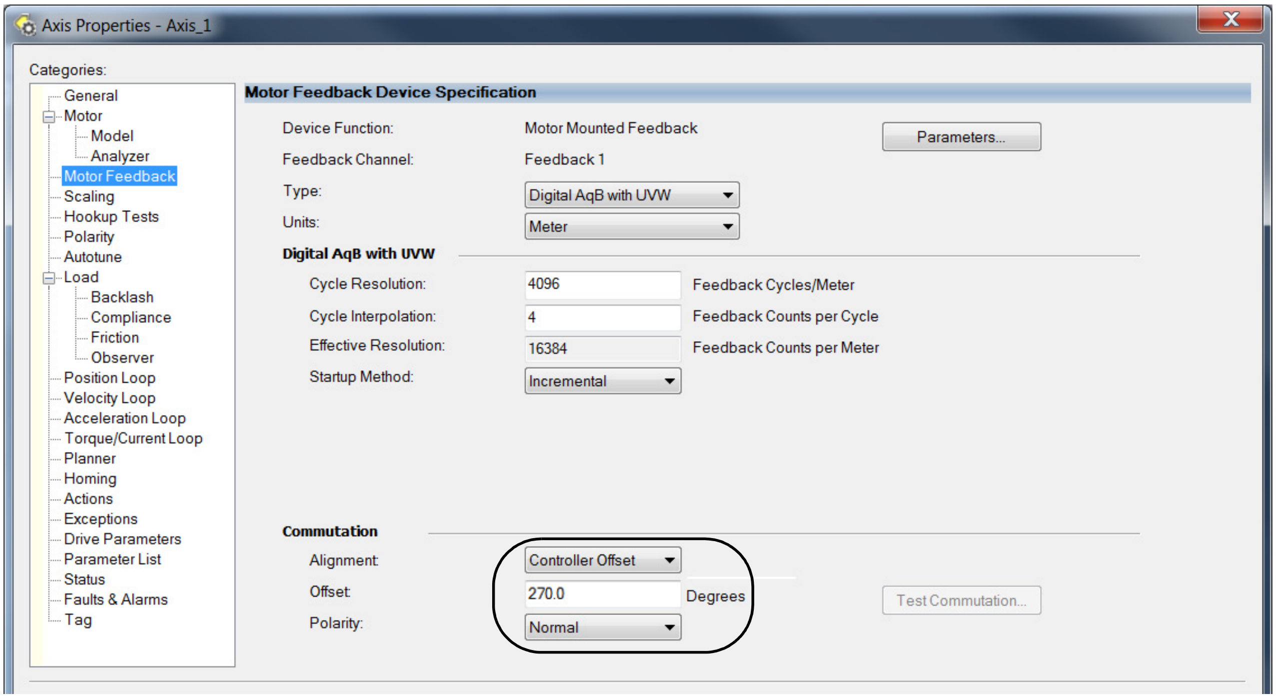
When the project is downloaded and online with the controller, the CIPAxisState status is typically Commutation Not Configured.

*Configure Commutation Attributes*

At this point, the drive has main power applied but is not energized (enabled).

Follow these steps to configure Commutation when Motor Offset is known by the manufacturer.

1. Select the Motor Feedback category.




2. From the Alignment dropdown menu, choose Controller Offset and enter the Offset value in degrees.

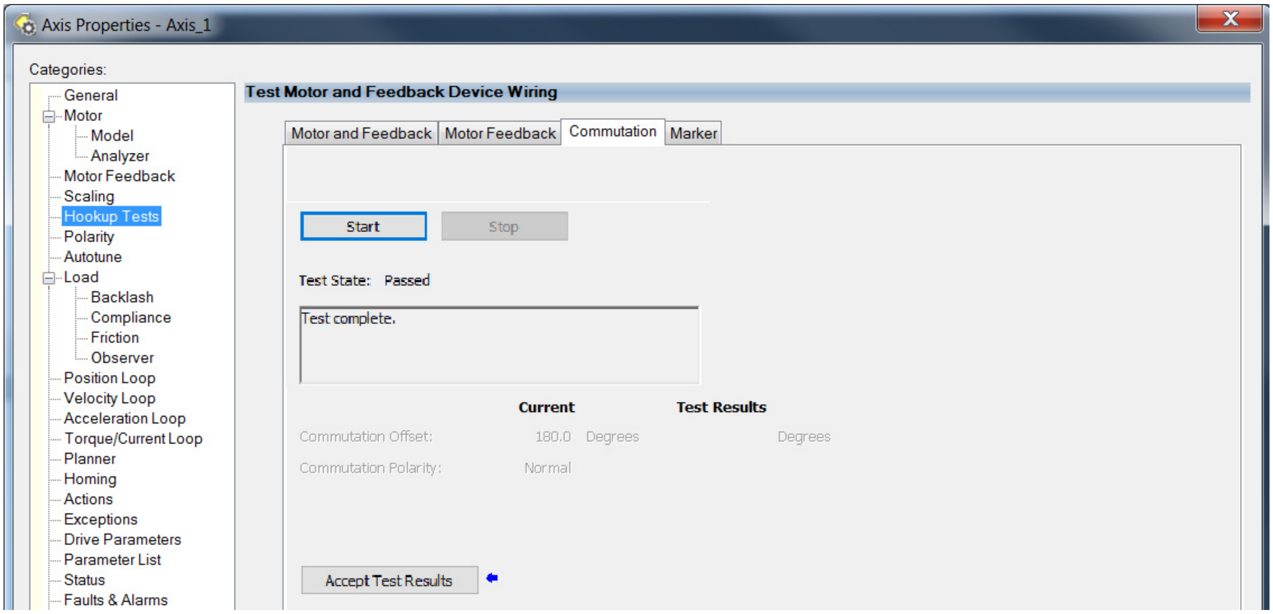
   In this example, the Motor Offset is 270 degrees.

3. Click Apply.

   If the motor offset is not known by the manufacturer, use the Hookup Tests category, Commutation Test tab to calculate and populate the commutation attributes.

Follow these steps to perform the Commutation Test when the Motor Offset is not known by the manufacturer.

1. Select the Hookup Tests category.

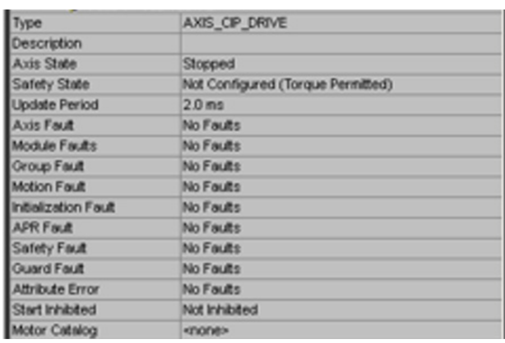



**IMPORTANT** Before you begin the Commutation Test, make sure to disconnect the motor from the load.

2. Click the Commutation tab.
3. Click Start.
4. Click Accept Test Results, if the test is complete.

If the Commutation test fails, see Troubleshoot Test Results on page 68 for suggestions on next steps if the test does not complete.

In the Controller Organizer, Axis Quick View, the axis is in the Stopped State.



*Run Hookup Tests*

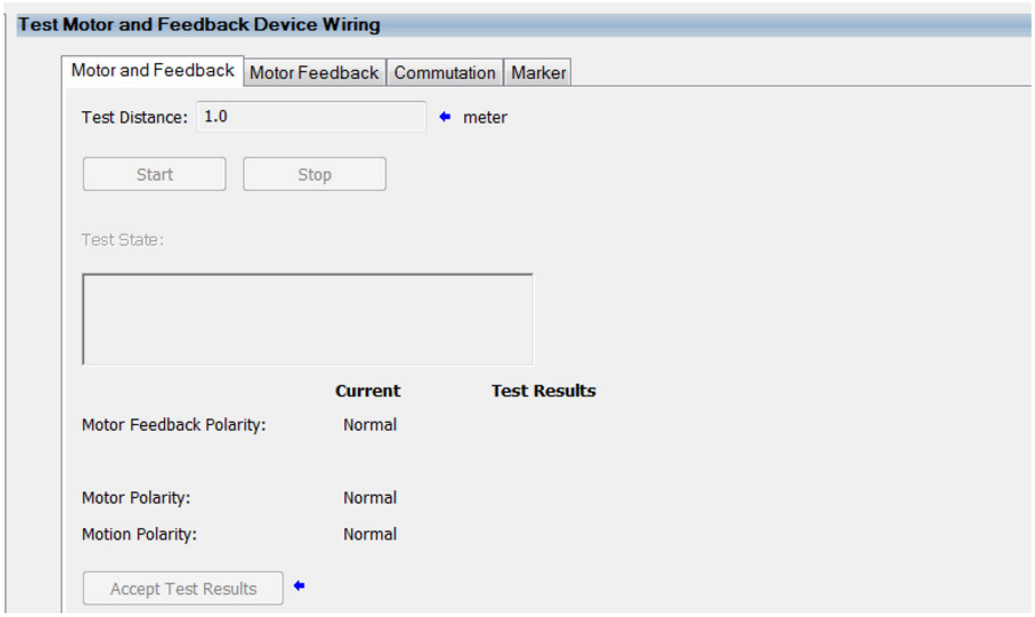
Follow these steps to perform additional Hookup Tests.

1. Select the Hookup Tests category.


| | |
|---|---|
| **IMPORTANT** | Disconnect the load from the motor when using Hookup Tests. |

2. Click the Motor Feedback tab.
    a. Enter 1.0 meter in the Test Distance field and click Start.
    b. Move the motor by hand, 1.0 meter.
    c. Click OK and Accept Test Results.
    d. If the Motor Feedback test fails, see Motor Feedback Test on page 71 for suggestions on next steps if the test does not complete.
    e. Click Apply.

3. Click the Motor and Feedback tab.




a. Enter 1.0 meter in the Test Distance field and click Start.

   The actuator will move 1.0 meter.

   Studio 5000 Logix Designer application asks if the axis movement was positive or negative.

b. Based on the machine requirement, if the axis moved in the positive direction, select yes. If it moved in the negative direction, select no.

c. Click Accept Test Results.

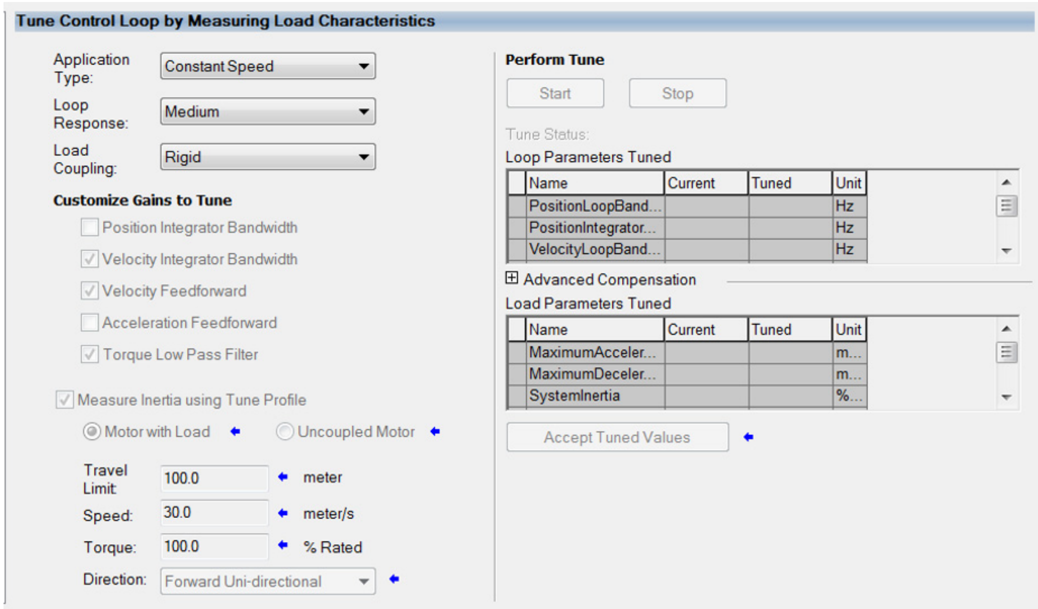
| | |
|---|---|
| **IMPORTANT** | The Motor and Feedback Test is required to be run once unless the drive or actuator is replaced. If such a replacement occurs, it may be possible that the test results remain valid. If you don’t know if the test results remain valid after the replacement, the test must be repeated. |

   If the Motor and Feedback test fails, see Motor and Feedback Test on page 71 for suggestions on next steps if the test does not complete.

d. Click Apply.

### *Run Autotune Tests*

1. Select the Autotune category.




a. If necessary, disconnect the load from the motor.

The Autotune Test outputs a step impulse to the motor. If the load cannot respond to this quick input (that is, this application has a low bandwidth or large inertia), disconnect the load before the Autotune test is executed.

If you execute the Autotune Test in this way (with only the motor), you will, at a minimum, have a similar characterization of the Kinetix motor catalog number. The application settings are applied and the Load Ratio is estimated. Deeper tuning than this is outside the scope of this document. You can see the Motion System Tuning Application Technique, publication MOTION-AT005, for additional guidance.

b. Configure the application type, loop response, and load coupling to what the machine application requires.

| | |
|---|---|
| **IMPORTANT** | See the Motion System Tuning Application Technique, publication MOTION-AT005, to determine the best tuning method for your machine application. |

c. Check the Measure Inertia using Tune Profile checkbox.

| | |
|---|---|
| **IMPORTANT** | Checking the Measure Inertia Using Tune Profile checkbox rotates the motor. If your load is coupled, see the Motion System Tuning Application Technique, publication MOTION-AT005, for additional information on the Autotune Test, or make sure that the Measure Inertia Using Tune Profile checkbox is not checked. |

d. Select the Motor with Load radio button.

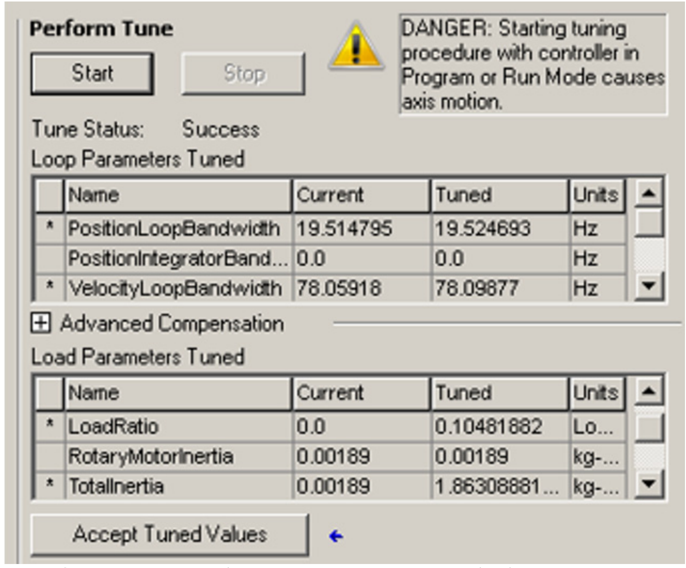
e. In the Travel Limit field, enter as long a travel limit as possible with the machine mechanics.

f. In the Speed field, enter approximately 50…75% of the Planner category maximum velocity.

g. In the Torque field, enter 100% of motor rated torque based on the machine application requirements.

h. Set Direction for rotation in one direction (Uni-directional) or both directions (Bi-directional).

2. Click Start.




3. If tuning is successful, replace the Current values with the Tuned values by clicking Accept Tuned Values. If tuning fails, see Autotune Test on page 72 for suggestions on next steps.
4. By using Motion Direct Commands, use different speeds and positions to verify performance.

| | |
|---|---|
| **IMPORTANT** | If the drive has not been enabled before this step (new installation), verify that you have safeguards in place to safely remove power from the drive if there is an unstable situation where the drive can produce undesired motion. |

5. Click Apply.

# Troubleshoot Test Results

Throughout the motor nameplate datasheet entry process, specific tests are performed in an attempt to produce accurate motor data for instances when motor nameplate or datasheet specifications are not available. Troubleshooting tables for faults that occur in the Kinetix drives are available in the Rockwell Automation Knowledgebase and the Kinetix drives user manuals. See Additional Resources on page 75 for a list of Kinetix drives user manuals.

This troubleshooting section provides insight and suggestions for when these tests fail. The following tests are described and used throughout the motor nameplate datasheet entry process.

**Table 23 - Motor Tests Used Throughout This Publication**

| Troubleshoot this Controller Organizer Category | Page | Used With These Motors | Test That Failed | Page for More Information on the Controller Organizer Category |
|---|---|---|---|---|
| Motor > Analyzer | 69 | Rotary Induction motors. | Calculate Model | 20 |
| | | | Static Motor Test | 21 |
| | | | Dynamic Motor Test | 21 |
| Hookup Tests | 71 | Induction or permanent-magnet motors with motor feedback. | Motor Feedback | 29 |
| | | Permanent-magnet motors with motor feedback. | Motor and Feedback | |
| | | | Commutation | 30 |
| Autotune Test | 72 | Induction or permanent-magnet motors with motor feedback. | Autotune | 50 |
| | | | | Motion System Tuning Application Technique, publication MOTION-AT005. |
| Motion Direct Commands | 73 | All | MSO, MAJ, MAM | See the Integrated Motion on the EtherNet/IP Network: Configuration and Startup User Manual, publication MOTION-UM003. |

# Motor > Analyzer Category Tests

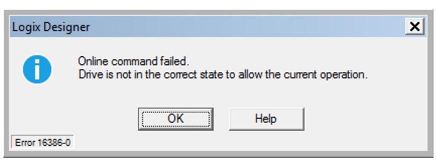
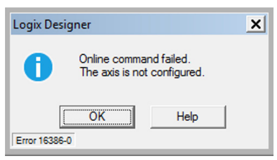
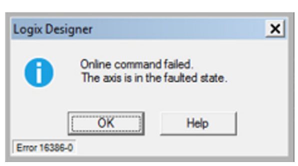
The Motor > Analyzer category tests apply to rotary induction motors with or without a motor feedback device. Use the Motor Tests and Autotune Matrix table on page 20 to determine which test to run.

## *Calculate Model Test*

The calculate model test is executed by the motion planner in the controller and does not energize the Kinetix drive IGBT. See Motor > Analyzer Category beginning on page 20 for more information on the calculate model test.

Table 24 provides guidance to correct some common problems that occur with the Calculate Model Test. See the Kinetix drives user manuals for additional troubleshooting help. See Additional Resources on page 75 for a list of Kinetix drives user manuals.

**Table 24 - Calculate Model Fails**

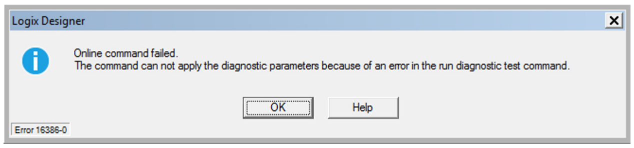
<table>
<tr><th>Potential Cause</th><th colspan="2">Possible Resolution</th></tr>
<tr><td>Motor nameplate data entry does not fit the typical induction motor equation that is found on page 14.</td><td colspan="2">• Motor poles versus motor speed versus motor frequency must match the equation<br>• If the motor nameplate does not supply this information, obtain the motor equivalent circuit diagram from the manufacturer.</td></tr>
<tr><td rowspan="4">The AxisCIPState was not in the Stopped state before the test was run.<br><br></td><td>AxisCIPState is in the Pre-Charge state.</td><td>• Apply AC power to the 2198-P*xxx* power supply.<br>• The 2198-P*xxx* power supply is in a faulted condition.<br>• The 2198-P*xxx* power supply has an enable input configured and is not powered.<br>• The 2198-P*xxx* DC connection busbar to the inverter is not connected or is loose.</td></tr>
<tr><td>AxisCIPState is in the Start Inhibited state.</td><td>• The specific inverter has an enable input configured in digital inputs, but is not powered.<br>• The inverter is in the STO Inhibit state.</td></tr>
<tr><td>AxisCIPState is in the Not Configured state.<br><br></td><td>• There is a configuration fault in the Axis_CIP_Drive (for instance, no motor feedback entered with position loop).<br>• The axis is not synchronized with the Grandmaster.<br>• An axis network or communication exists.<br>• See Knowledgebase https://rockwellautomation.custhelp.com/app/answers/answer_view/a_id/1047243 for communication and network.</td></tr>
<tr><td>AxisCIPState is in the Faulted state.<br><br></td><td>• Review the CIP Axis status or fault and alarm properties for a fault indicator.<br>• Drive is showing FLT S07 or FLT S08 (motor overload) fault codes.<br>– An induction motor normally has a service factor, therefore enter the motor nameplate value so the thermal counter does not increase until this percentage is exceeded. If the motor service factor is 1.1, adjust the motor overload limit to 110%.<br>– If using an open-loop frequency mode, the motor current is derated below 20 Hz to protect the motor. This derating can be changed with an Explicit MSG instruction for motor overload or parameter bb9 (Hex) (default at 20 Hz to start the derate).<br>– Do not run an induction motor in frequency control mode at 0 Hz. Instead, use the Motion Servo Off instruction to disable the drive at 0 Hz.<br>– Motor nameplate data entry does not fit the typical squirrel cage equation that is found on page 14.<br>• Drive is showing FLT S10 (inverter overcurrent) or FLT S16 (ground current) fault codes.<br>– Make sure that the motor power (MP) connector has no shorted or arcing wires. If applicable, verify this at the drive end and at the motor end.<br>– Perform a motor electrical insulation resistance test. See Knowledgebase https://rockwellautomation.custhelp.com/app/answers/detail/a_id/42078<br>– Remove the motor power cable from the drive (when the drive is in a safe state) and check if the drive goes into an overcurrent condition. If it does not, the motor must be further evaluated for the cause of an overcurrent condition. If it does, replace the drive.<br>– Motor nameplate data entry does not fit the typical squirrel cage equation that is found on page 14.</td></tr>
</table>

### *Static Motor Test*

The Static Motor Test energizes the drive, performs an R1 resistance and rotor/stator reactance measurement, and then calculates the other motor model parameters. See Motor > Analyzer Category beginning on page 20 for more information on the static motor test.

Table 25 provides guidance to correct some common problems that occur with the Static Motor Test. See the Kinetix drives user manuals for additional troubleshooting help. See Additional Resources on page 75 for a list of Kinetix drives user manuals.

**Table 25 - Static Motor Test Fails**

<table>
<tr><th>Potential Cause</th><th colspan="2">Possible Resolution</th></tr>
<tr><td>All potential causes that apply to the Calculate Model Test.</td><td colspan="2">All possible resolutions in the Calculate Model Test section.</td></tr>
<tr><td>An error in the Run Diagnostic Command appears:<br>
</td><td>The error indicates that the drive cannot perform the Static Model test. The Static Model test energizes the Kinetix drive solely to measure the R1 resistance. Evaluate all Kinetix drive-to-motor connections, considering the possible issues listed to the right.</td><td>• Drive-to-motor cables longer than the recommended maximum length:<br>– Kinetix 5700 maximum length is 90 m (295 ft).<br>– Kinetix 5500 maximum length is 50 m (164 ft).<br>– Kinetix 5300 maximum length is 30 m (98 ft).<br>• An open wire from the Kinetix drive to the motor.<br>• The motor having a dual winding of 230/460V AC and wired for 230V AC instead of 460V AC.<br>• Loose wires in the motor thermal block causing an arc, short, or path to ground.<br>• If using a 2198-Dxxx-ERSx dual-axis inverter and using the Axis 3 port rather than the Axis 1 port.</td></tr>
<tr><td>Axis velocity or current vector limits are set to 0 by mistake.</td><td colspan="2">Enter the correct values.</td></tr>
<tr><td>The controller is in RUN mode and executing motion commands in the logic program such as a Motion Servo Off or other that interferes with the Static test.</td><td colspan="2">If possible, change the controller to Remote Program mode during configuration and performance testing. This helps prevent the logic from scanning. The use of Motion Direct Commands is suggested during startup.</td></tr>
<tr><td>If the induction motor is configured as closed loop, it is possible that the encoder wiring, resolution, and direction must be evaluated.</td><td colspan="2">• For the specific motor encoder being used, see the connected feedback port wiring in the user manual for your Kinetix drive, which can be found in the Additional Resources on page 75.<br>• Motor Feedback tab must match the data entry for resolution.<br>• The motor feedback polarity can be adjusted to Normal or Inverted in the Polarity category dialog box.</td></tr>
</table>

### *Dynamic Motor Test*

During the dynamic motor test, the Kinetix 5300 or Kinetix 5700 drive attempts to rotate the motor to 75% of base speed for an accurate measurement of the Motor > Analyzer parameters. See Motor > Analyzer Category beginning on page 20 for more information on the dynamic motor test.

Table 26 provides guidance to correct some common problems that occur with the Dynamic Motor Test. See the Kinetix drives user manuals for additional troubleshooting help. See Additional Resources on page 75 for a list of Kinetix drives user manuals.

**Table 26 - Dynamic Motor Test Fails**

| Potential Cause | Possible Resolution |
|---|---|
| All potential causes that apply to the Calculate Model and Static Motor tests. | All possible resolutions in the Calculate Model and Static Motor test sections. |
| The axis scaling does not match that of the transmission. | Axis Properties for scaling must be set for the proper transmission on the motor. For instance, if a 10:1 gearbox is used, the motor rotates 10 times for every 1 rotation of the gearbox. |
| The motor shaft does not move (rotate). | If the motor is connected to a large load, disconnect the load from the motor. |
| | If a holding or stopping brake is used, make sure that the brake is able to engage and release freely so the motor shaft can rotate. See Knowledgebase https://rockwellautomation.custhelp.com/app/answers/detail/a_id/68763 for the proper way to test if the brake releases correctly with an SSV command. |
| Axis torque limits are set too low to move the motor to 75% of base speed. | Review the Torque/Current Loop tab for these limits. Torque limits are only applicable with a position/velocity/current loop that requires feedback. |
| The 2198-P*xxx* power supply cannot handle the amount of regenerative energy this test can generate during the deceleration. | Review the 2198-P*xxx* power supply Module Properties (Power tab) for shunt and proper sizing. See the Motion Analyzer System Sizing and Selection Tool https://motionanalyzer.rockwellautomation.com/ for more information. Alternately, you can use FactoryTalk Motion Analyzer, which can be downloaded from the Product Compatibility Download Center, using the search term “FactoryTalk Motion Analyzer”. |

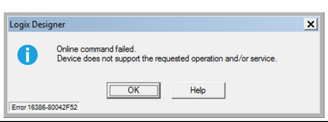
## Hookup Tests Category

The Hookup Tests are used with induction and permanent-magnet motors with motor feedback. Use the Motor Tests and Autotune Matrix table on page 20 to determine which test to run.

### *Motor and Feedback Test*

See Hookup Tests Category beginning on page 29 for more information on the motor and feedback test.

**Table 27 - Motor and Feedback Test Fails**

| Motor Type | Potential Cause | Possible Resolution |
|---|---|---|
| Induction (not supported) | Induction motors do not support this test. Any attempt results in the following error message:<br> | • The Motor and Feedback test is not supported with rotary induction motors. The Motor Feedback and Marker tests should be used instead. See Hookup Tests Category, Rotary Induction Motor section on page 29.<br>• If the motor polarity must be changed, go to the Polarity tab and change the setting. |
| Permanent magnet (supported) | The Calculate Model, Static Motor, Dynamic Motor, and Motor Feedback tests are potential causes of this motor type failing. | If this test fails, all Calculate Model, Static Motor, Dynamic Motor, and Motor Feedback possible resolutions apply when troubleshooting. |

### *Motor Feedback Test*

See Hookup Tests Category beginning on page 29 for more information on the motor feedback test.

**Table 28 - Motor Feedback Test Fails**

| Motor Type | Potential Cause | Possible Resolution |
|---|---|---|
| Induction and permanent-magnet motors with motor feedback. | The motor shaft does not move (rotate). | If the motor includes a holding brake that is used in the application, see the Dynamic Motor Test Fails table, potential cause: The motor shaft does not move (rotate), for more information on testing holding brakes. |
| | The Calculate Model, Static Motor, and Dynamic Motor tests are potential causes of this motor type failing. | If this test fails, all Calculate Model, Static Motor, and Dynamic Motor possible resolutions apply when troubleshooting. |

### *Commutation Test*

The Commutation test applies only to permanent-magnet motors with motor feedback. See Hookup Tests Category beginning on page 29 for more information on the commutation test.

**Table 29 - Commutation Test Fails**

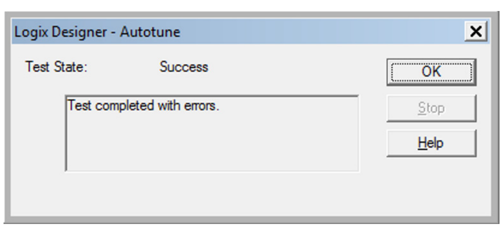
| Motor Type | Potential Cause | Possible Resolution |
|---|---|---|
| Permanent-magnet motors with motor feedback. | The motor shaft does not move (rotate). | If the motor includes a holding brake that is used in the application, make sure that the holding brake is able to release properly. See the Dynamic Motor Test Fails table on page 71, potential cause: The motor shaft does not move (rotate), for information on how to manually release the holding brake (if required). |
| | The motor shaft does not move (rotate) and is connected to a large load. | • Disconnect the load from the motor shaft.<br>• Always run the commutation test with the motor disconnected from the load, disconnect any gearbox, pulley, or load transmission. |
| | Motor power wiring is not phased correctly matching the feedback device. | • U, V, and W phasing must match that of the motor manufacturers feedback device, especially in an AqB motor feedback application. Obtain motor manufacturing document or call the vendor to discuss.<br>• Adjust the phase shift in U to V and V to W, then W to U. |
| | Hall Effect sensors do not match the power wiring. | Halls signals are required for an AqB or Sine/Cosine type encoder and must be phased properly (120° apart). |
| | All Calculate Model, Static Motor, and Dynamic Motor, Motor Feedback, and Motor and Feedback tests are potential causes of this motor type failing. | If this test fails, all Calculate Model, Static Motor, Dynamic Motor, Motor Feedback, and Motor and Feedback possible resolutions apply when troubleshooting. |

## Autotune Test

The Autotune test applies to position loop or velocity loop configurations. The Autotune test measures the system inertia for performance calculations. When troubleshooting an Autotune test failure, note when the Autotune test fails. For example, when you click Start or during the actual Autotune movement. Use the Table 30 to help assist you through those actual Autotune failures. See the Motion System Tuning Application Technique, publication MOTION-AT005, for additional help with tuning your axis.

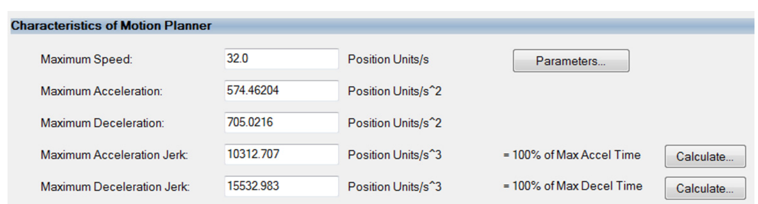
**Table 30 - Autotune Test Fails**

<table>
<tr><th>Potential Cause</th><th>Possible Resolution</th></tr>
<tr><td>
An error during Autotune appears:



</td><td>

• Review the Autotune section for your motor type. This begins with Run Autotune on page 50.

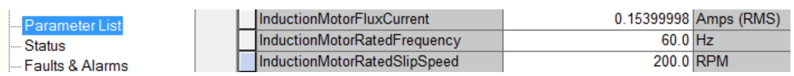



• Make sure that the Maximum Speed, Acceleration, and Deceleration units reflect the motor maximum speed based on the nameplate data and the Rated Speed.<br>
• Enter a Maximum Tuning Speed that allows the motor to accelerate to at least 25% of the motor's base speed.<br>
• Make sure that the Tuning travel distance allows the motor to run (under load) at this speed for as long a distance as possible.<br>
• Try the Manual Tune or Load Observer features. See the Motion System Tuning Application Technique, publication MOTION-AT005, for additional help with tuning your axis.
</td></tr>
<tr><td>If the Autotune test fails, all Calculate Model, Static Motor, and Dynamic Motor, Motor Feedback, Motor and Feedback, and Commutation test potential causes apply when troubleshooting.</td><td>If this test fails, all Calculate Model, Static Motor, Dynamic Motor, Motor Feedback, Motor and Feedback, and Commutation test possible resolutions apply when troubleshooting.</td></tr>
</table>

# Motion Direct Commands

Use Motion Direct Commands (MDCs) to run individual motion commands on the axis. We recommend having the processor in PROGRAM mode to help prevent your logic from influencing any of the Motion Direct Commands. Having the processor in PROGRAM mode may not be possible if your safety system interlocks use a safety controller. It is typical for those outputs to be cleared when the controller is in REM Program mode.

**Table 31 - Performance or Motion Direct Commands Issues**

| Potential Cause | Possible Resolution |
|---|---|
| The motor speed is reduced or the motor cannot achieve the commanded speed (Frequency Control mode with Basic Volts/Hz or Sensorless Vector control). | • Evaluate the AxisName.CommandVelocity and the AxisName.OutputFrequency or AxisName.VelocityFeedback tags to determine if they match.<br>• Scaling category has an incorrect setting. Check units per second versus the motor revolution or load revolution per second induction motor in Frequency Control mode only.<br>• A motion instruction is not being used correctly. For example, when using units of percent of maximum rather than units per second or meters per second in a linear permanent-magnet application. Thus, the use of Motion Direct Commands and if possible switch the program to remote program to eliminate programming instructions.<br>• Setting for Slip Compensation InductionMotorRatedSlipSpeed equals 0 (induction motor in Frequency Control mode only).<br><br>• Motor flux current is too low or too high. See Motor Flux Current Versus Motor Power Guidelines on page 19 for the power ranges and typical flux current values. Also, the use of the motor equivalent circuit diagram would be useful to compare the calculated versus the measured values (induction motor in Frequency Control mode only).<br>• Check the motor IR, stator/rotor leakage, and resistance. Loss of torque or the ability to accelerate up to speed could be the result of incorrect nameplate settings. The use of the motor equivalent circuit diagram would be useful to compare the calculated versus the measured values (induction motor in Frequency Control mode only).<br>• Motor torque/current limit category settings are too low for the commanded speed. These peak torque values are in motor percent rated current. A simple RSTrend could indicate if the commanded velocity versus actual velocity is being limited while evaluating current feedback.<br>• Measure the actual output voltage with a voltmeter. Measure the voltage from motor phases U to V, V to W, and U to W. Typically, if a motor is rated 460V AC, 60 Hz, 1750 rpm, you should measure approximately 230V AC on all three phases (plus or minus a few volts) when running at 30 Hz or 14.6 rev/second. All voltages should be similar, otherwise the motor or the drive might be the reason for the reduced speed condition. Disconnecting motor power (when voltages are safe), and measuring the voltage between motor phases again can also indicate if the drive is attempting to accelerate the motor to the commanded speed.<br>• Incorrect tuning values. If Autotune doesn't work, try the Manual Tune or Load Observer features. See the Motion System Tuning Application Technique, publication MOTION-AT005, for additional help with tuning.<br>• The drive could be current limiting the motor, preventing it from reaching the commanded speed. Reduce the acceleration rate or increase the positive/negative torque limits.<br>• The controller is in Remote Run mode and other motion commands in your logic programs could be interfering with the Motion Direct Commands. Place the controller in Remote Program mode and execute motion direct commands. |
| Machine position does not match the required position. | Check all scaling and feedback configurations as outlined previously in any of the applicable Hookup tests as possible resolutions to apply when troubleshooting. |
| Error code FLT S47, Feedback Device Failure | • Check motor feedback wiring.<br>• Check that motor feedback port is correct per associated axis.<br>• Check that motor feedback power is correct. |
| • Error code FLT S54, Excessive Position Error<br>• Error code FLT S55, Excessive Velocity Error | • Incorrect tuning values. If Autotune doesn't work, try:<br>– Manual Tune or Load Observer features.<br>– See the Motion System Tuning Application Technique, publication MOTION-AT005, for additional help with tuning.<br>• Check for motor holding brake or other external loading on the motor.<br>• Check for mechanical or machine coupling/slippage.<br>• Check for position and velocity error limits set too low based on drive/motor ability or configuration/ tuning. |
| Other Kinetix drive faults. | For troubleshooting tables, see the user manual for your Kinetix drive, available in the Additional Resources on page 75. |
| Motor current loop is unstable or there is a high current draw. | • Commutation angle is incorrect (applies to rotary and linear SPM motors only).<br>• The Motor > Model category has an incorrect inductance value. Make sure that the correct units are used. For example, the entry of 8.2 mH was entered as 8.2 H (applies to rotary and linear SPM motors only). The correct value is 0.0082. |

# Notes:

# Additional Resources

These documents contain additional information concerning related products from Rockwell Automation. You can view or download publications at rok.auto/literature.

| Resource | Description |
|---|---|
| Kinetix Rotary Motion Specifications Technical Data, publication KNX-TD001 | Product specifications for Kinetix VPL, VPC, VPF, VPH, VPS, Kinetix MPL, MPM, MPF, MPS; Kinetix TL and TLY, Kinetix RDB, Kinetix MMA, and Kinetix HPK rotary motors. |
| Kinetix 5700 Servo Drives User Manual, publication 2198-UM002 | Provides information on installing, configuring, startup, troubleshooting, and applications for your Kinetix servo drive system. |
| Kinetix 5500 Servo Drives User Manual, publication 2198-UM001 | |
| Kinetix 5500 Servo Drives Installation Instructions, publication 2198-IN001 | |
| Kinetix 5300 Single-axis EtherNet/IP Servo Drives User Manual, publication 2198-UM005 | |
| Kinetix 5300 Single-axis EtherNet/IP Servo Drives Installation Instructions, publication 2198-IN021 | |
| Kinetix 6200 and Kinetix 6500 Modular Multi-axis Servo Drives User Manual, publication 2094-UM002 | |
| Kinetix 350 Single-axis EtherNet/IP Servo Drives User Manual, publication 2097-UM002 | |
| System Design for Control of Electrical Noise Reference Manual, publication GMC-RM001 | Provides information, examples, and techniques designed to minimize system failures caused by electrical noise. |
| Kinetix Motion Control Selection Guide, publication KNX-SG001 | Provides an overview of Kinetix servo drives, motors, actuators, and motion accessories designed to help make initial decisions for the motion control products best suited for your system requirements. |
| Motion System Tuning Application Technique, publication MOTION-AT005 | Provides information on tuning a Kinetix drive system. |
| Integrated Motion on the EtherNet/IP Network Reference Manual, publication MOTION-RM003 | Provides information on the AXIS_CIP_DRIVE attributes and the Studio 5000 Logix Designer application Control Modes and Methods. |
| Rockwell Automation Product Selection website http://www.rockwellautomation.com/global/support/selection.page | Provides online product selection and system configuration tools, including AutoCAD (DXF) drawings. |
| Motion Analyzer System Sizing and Selection Tool website https://motionanalyzer.rockwellautomation.com/ | Provides a comprehensive motion application sizing tool used for analysis, optimization, selection, and validation of your Kinetix Motion Control system. |
| Product Certifications website, rok.auto/certifications | Provides declarations of conformity, certificates, and other certification details. |
| Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1 | Provides general guidelines for installing a Rockwell Automation industrial system. |

## Rockwell Automation Support

Use these resources to access support information.

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| **Technical Support Center** | Find help with how-to videos, FAQs, chat, user forums, Knowledgebase, and product notification updates. | rok.auto/support |
| **Local Technical Support Phone Numbers** | Locate the telephone number for your country. | rok.auto/phonesupport |
| **Technical Documentation Center** | Quickly access and download technical specifications, installation instructions, and user manuals. | rok.auto/techdocs |
| **Literature Library** | Find installation instructions, manuals, brochures, and technical data publications. | rok.auto/literature |
| **Product Compatibility and Download Center (PCDC)** | Download firmware, associated files (such as AOP, EDS, and DTM), and access product release notes. | rok.auto/pcdc |

## Documentation Feedback

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Rockwell Automation maintains current product environmental compliance information on its website at rok.auto/pec.

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