Application Technique

Original Instructions

Allen-Bradley by ROCKWELL AUTOMATION

Virtual Torque Sensor

Kinetix 5700 and Kinetix 5300 Servo Drives

Rockwell Automation

Notes:

Introduction

Virtual Torque Sensor (VTS) was introduced in Studio 5000 Logix Designer® version 33.00 with Kinetix® 5700 and Kinetix 5300 drives. This feature estimates the motor air-gap torque which can be used to monitor machine operation, diagnose faults on the mechanical system, and assist in maintenance and commissioning.

The motor air-gap torque includes the load torque, motor torque losses, and rotor acceleration torque. The estimated torque does not affect motion control or drive performance and is provided as a cyclic parameter called Torque Estimate that can be read in the controller at the coarse update period, or data logged at the servo update period.

The Torque Estimate can be filtered by two configurable filters. These filters can be configured as second-order low-pass, notch, lead-lag, or lag-lead. The first filter is configured by default as a second-order low-pass filter with bandwidth of 100 Hz. The second filter is disabled by default and is configured as a notch filter.

The description of all parameters associated with the Virtual Torque Sensor, methods to configure these two filters, and examples of applications for this feature are provided in this document.

Download Firmware, AOP, EDS, and Other Files

Download firmware, associated files (such as AOP, EDS, and DTM), and access product release notes from the Product Compatibility and Download Center at rok.auto/pcdc.

Required Software

The Virtual Torque Sensor is available with the following hardware and software:

- Studio 5000 Logix Designer version 33.00 and later
- Kinetix 5700 ERS3 Series B and ERS4 Series A, firmware 13.10 and later
- Kinetix 5300, firmware 13.10 and later

Associated Catalog Numbers

Table 1 - Kinetix 5700 and Kinetix 5300 Catalog Numbers that Support VTS

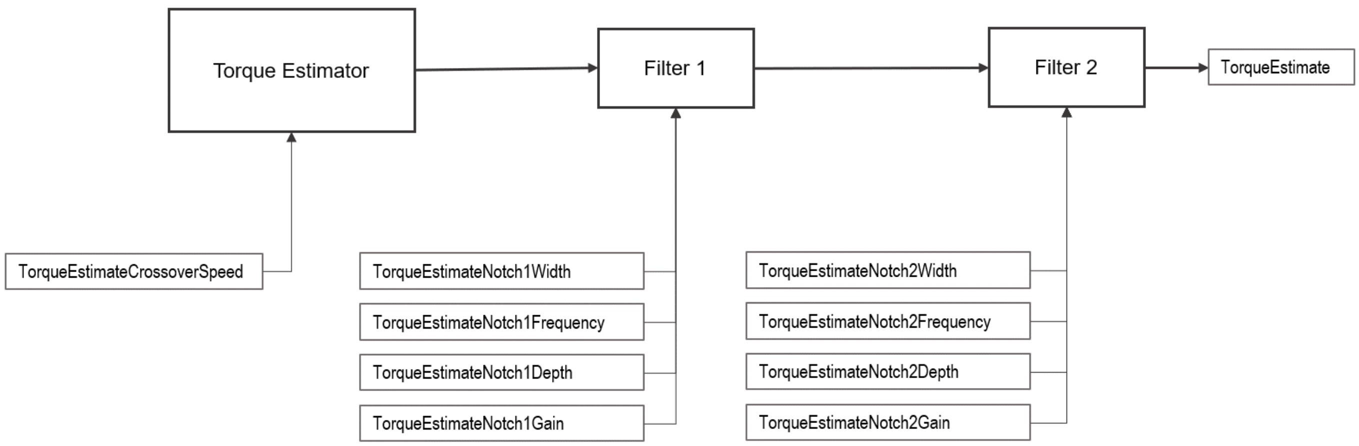
Kinetix 5700		
2198-D006-ERS3	2198-S312-ERS3	2198-D057-ERS4
2198-D012-ERS3	2198-S160-ERS3	2198-S086-ERS4
2198-D020-ERS3	2198-S263-ERS3	2198-S130-ERS4
2198-D032-ERS3	2198-D006-ERS4	2198-S160-ERS4
2198-D057-ERS3	2198-D012-ERS4	2198-S263-ERS4
2198-S086-ERS3	2198-D020-ERS4	2198-S312-ERS4
2198-S130-ERS3	2198-D032-ERS4	–

Kinetix 5300	
2198-C1004-ERS	2198-C4004-ERS
2198-C1007-ERS	2198-C4007-ERS
2198-C1015-ERS	2198-C4015-ERS
2198-C1020-ERS	2198-C4020-ERS
2198-C2030-ERS	2198-C4030-ERS
2198-C2055-ERS	2198-C4055-ERS
2198-C2075-ERS	2198-C4075-ERS

Settings and Parameters

The core block diagram of the Virtual Torque Sensor is shown in Figure 1.

Figure 1 - VTS Core Block Diagram



The description of each of the Virtual Torque Sensor parameters is provided in Table 2.

Table 2 - Parameter Description (Data Type of all parameters is REAL)

Attribute name	Definition	Units	Limits	Notes
Torque Estimate	Estimated motor air-gap torque. Includes components of load torque, motor losses, and rotor acceleration torque.	% of Motor Rated Torque (Continuous Stall Torque)	Min: N/A Max: N/A	• Noise <1% • Accuracy >95% of motor rated torque above 20% motor rated speed • Default bandwidth is 100 Hz and it can be set up to 1 kHz.
Torque Estimate Crossover Speed	The motor speed at which the torque estimate transitions between two different estimation methods that are used to calculate the Torque Estimate attribute value.	Position Units/sec	Min: 0 Max: $3.4x10^{38}$ Default: 20% of motor rated speed	Crossover speed can be reduced at the expense of Torque Estimate noise at low speed.
Torque Estimate Notch 1 Frequency	The frequency of the first filter when configured as a notch. Otherwise, it is the bandwidth of the first filter. A value of zero disables the first filter.	Hz	Min: 0 Max: 2500 Hz Default: 100 Hz	The first filter is enabled by default.
Torque Estimate Notch 1 Gain	Sets the high frequency gain of the first torque estimate filter. The gain at high frequency will be twice the value set in this attribute. For notch filter operation, the value for this attribute is set to 1. A value greater than 1 results in a lead-lag filter function and a value less than 1 results in a lag-lead filter function. A value of 0 results in a second-order low-pass filter function.	Unitless	Min: 0 Max: 100 Default: 0.0	The first filter is set by default as a second-order low-pass filter.
Torque Estimate Notch 1 Width	The width of the first filter when configured as a notch. Higher value makes the notch filter wider. When the filter is configured as low-pass, lead-lag, or lag-lead, this attribute is the damping.	Unitless	Min: 0 Max: 10,000 Default: 1.0	–
Torque Estimate Notch 1 Depth	The depth of the first filter when configured as a notch. Lowering the value increases the attenuation at the Torque Estimate Notch 1 Frequency. A value of zero provides max attenuation. When the filter is configured as lead-lag or lag-lead, this attribute is the attenuation defined at the Frequency = Torque Estimate Notch 1 Frequency/Torque Estimate Notch 1 Gain.	Unitless	Min: 0 Max: 10,000 Default: 0.0	–
Torque Estimate Notch 2 Frequency	The frequency of the second filter when configured as a notch. Otherwise, it is the bandwidth of the filter. A value of zero disables the filter.	Hz	Min: 0 Max: 2500 Hz Default: 0.0	The second filter is disabled by default.

Table 2 - Parameter Description (Data Type of all parameters is REAL) (Continued)

Attribute name	Definition	Units	Limits	Notes
Torque Estimate Notch 2 Gain	Sets the high frequency gain of the second torque estimate filter. The gain at high frequency will be twice the value set in this attribute. For notch filter operation, the value for this attribute is set to 1. A value greater than 1 results in a lead-lag filter function and a value less than 1 results in a lag-lead filter function. A value of 0 results in a second-order low-pass filter function.	Unitless	Min: 0 Max: 100 Default: 1.0	The second filter is set by default as a notch filter.
Torque Estimate Notch 2 Width	The width of the second filter when configured as a notch. Higher values make the notch filter wider. When the filter is configured as low-pass, lead-lag, or lag-lead, this attribute is the damping.	Unitless	Min: 0 Max: 10,000 Default: 0.707	–
Torque Estimate Notch 2 Depth	The depth of the second filter when configured as a notch. Lowering the value increases the attenuation at the Torque Estimate Notch 2 Frequency. A value of zero provides max attenuation. When the filter is configured as lead-lag or lag-lead, this attribute is the attenuation defined at the Frequency = Torque Estimate Notch 2 Frequency / Torque Estimate Notch 2 Gain.	Unitless	Min: 0 Max: 10,000 Default: 0.0	–

Types of Filters

The first and second filter of the Torque Estimate can be configured as a second-order low-pass filter, notch filter, lag-lead filter, lead-lag filter, or disabled as shown in Table 3.

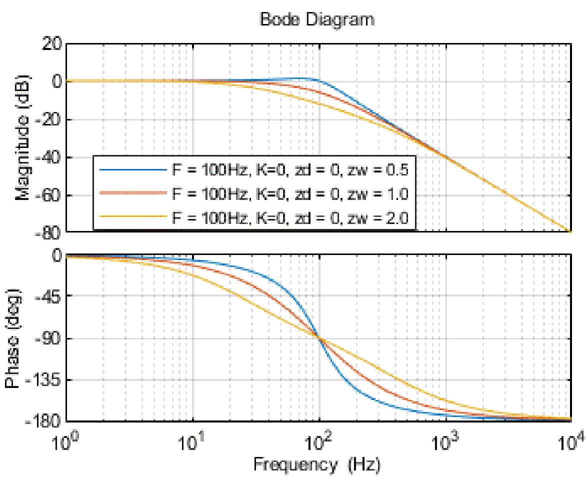
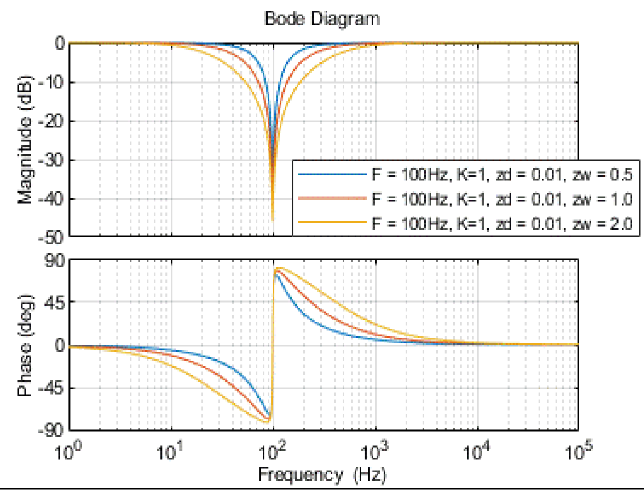
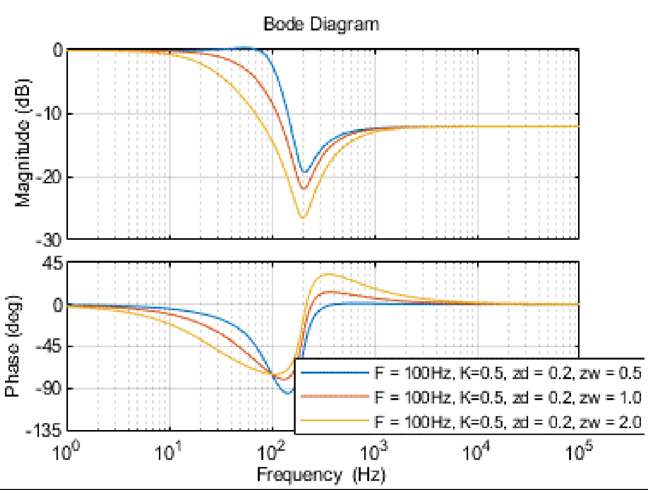
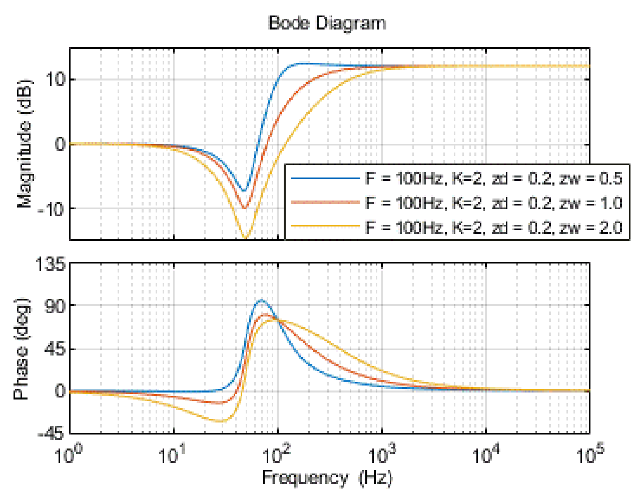
Table 3 - Filter Configuration

Attribute	Second-order Low-pass	Notch	Lag-Lead	Lead-lag	Disabled
Torque Estimate Notch Frequency (F)	Bandwidth (this is the frequency when the phase lag is -90°)	Notch filter frequency	Bandwidth	Bandwidth	0
Torque Estimate Notch Gain (K)	0	1	From 0 to less than 1	Greater than 1	Any value
Torque Estimate Notch Width (zW)	Damping (lag) zW < 1: Under damped zW = 1: Critically damped zW > 1: Over damped	Notch filter width	Damping (lag) zW < 1: Under damped zW = 1: Critically damped zW > 1: Over damped	Damping (lag) zW < 1: Under damped zW = 1: Critically damped zW > 1: Over damped	Any value
Torque Estimate Notch Depth (zD)	Any value can be used since it has no effect when the filter is configured as a low-pass filter.	Notch filter depth. A value of zero provides maximum attenuation of the notch frequency.	Depth (lead). Defined the attenuation at the frequency defined as F/K. A value of zero provides maximum attenuation.	Depth (lead). Defined the attenuation at the frequency defined as F/K. A value of zero provides maximum attenuation.	Any value

Filter Examples

Some examples of the four types of filters are shown in Table 4. See Motion System Tuning Application Technique, publication MOTION-AT005 for additional information on filters.

Table 4 - Examples of Filter Settings

<table>
<tr><th>Second-order Low-pass Filter</th><th>Notch Filter</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><th>Lag-lead Filter</th><th>Lead-lag Filter</th></tr>
<tr><td>
</td><td>
</td></tr>
</table>

Virtual Torque Sensor (VTS) Configuration

Follow these steps to configure VTS.

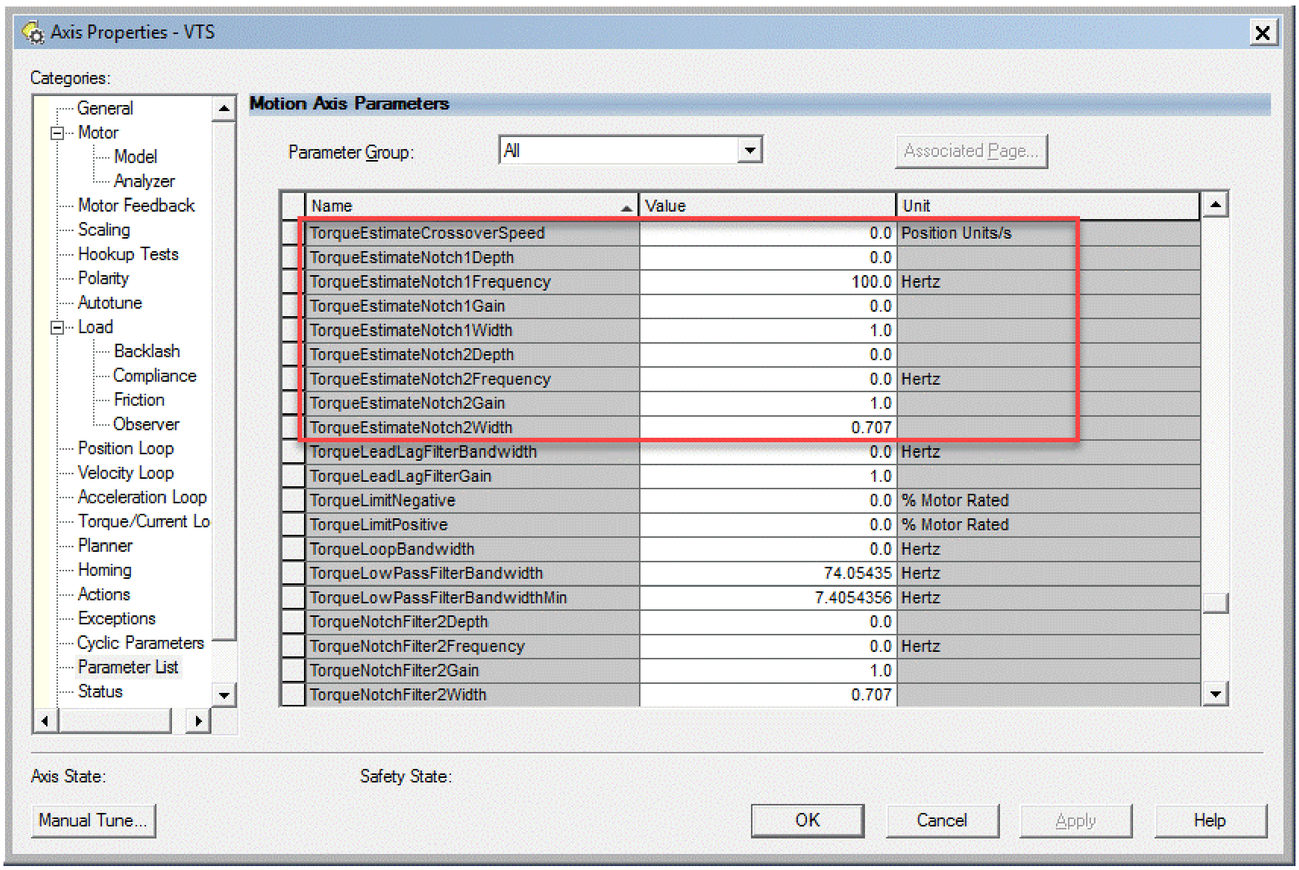
1. Open Studio 5000 Logix Designer version 33.00 or later.
2. Add a Kinetix 5700 servo drive or a Kinetix 5300 servo drive to the I/O Configuration.
3. Create an AXIS_CIP_DRIVE Axis under the Motion Group.
4. Open the Axis Properties and associate it to the Kinetix 5700 or Kinetix 5300 drive.
5. Select Parameter List in the Axis Properties (or, select the Torque/Current Loop tab and click the Parameters button) and locate the VTS parameters as shown in Figure 2.

6. Configure the following parameters of the first and second filter to attenuate the noise in the Torque Estimate when necessary.

   These parameters are described in Table 2 and Table 3. The procedure to configure the first and second filter as a low-pass and notch filter is described in Configure a Low-pass Filter and Configure a Notch Filter. These parameters can also be set via the Set System Value (SSV) instruction.

   - Torque Estimate Notch 1 Frequency
   - Torque Estimate Notch 1 Gain
   - Torque Estimate Notch 1 Width
   - Torque Estimate Notch 1 Depth
   - Torque Estimate Notch 2 Frequency
   - Torque Estimate Notch 2 Gain
   - Torque Estimate Notch 2 Width
   - Torque Estimate Notch 2 Depth

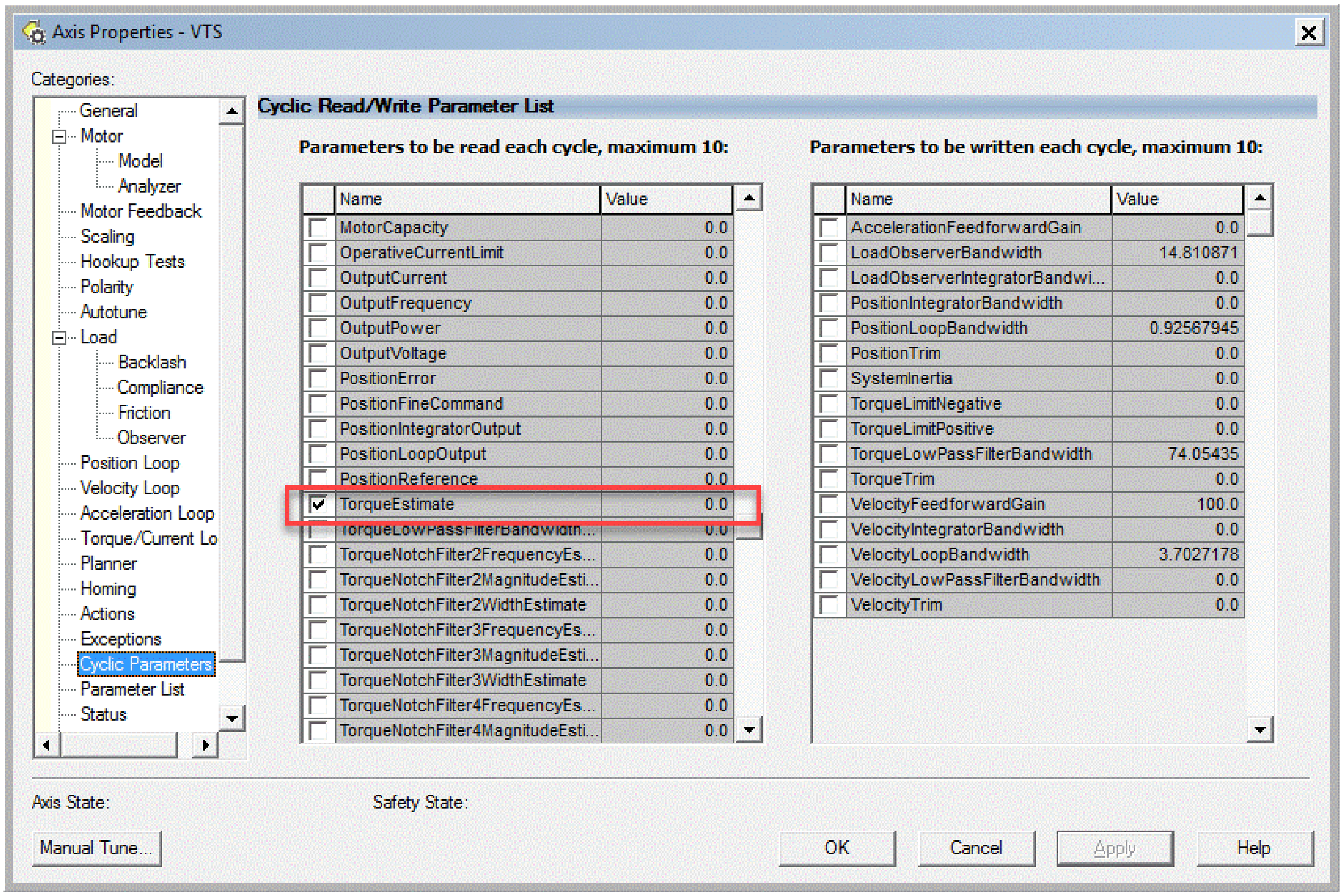
Figure 2 - Axis Properties with Virtual Torque Sensor Parameters



7. Adjust the Torque Estimate Crossover Speed to a lower value than the default if necessary. The default value is generally satisfactory. As the Torque Estimate Crossover Speed is reduced, higher noise is expected in Torque Estimate.

8. Select Cyclic Parameters and check the box for Torque Estimate:

Figure 3 - Enable Torque Estimate in Axis Properties - Cyclic Parameters



Configure a Low-pass Filter

Either or both filters shown in Figure 1 can be configured as a second-order low-pass filter. The first filter is set by default as a second-order low-pass filter with bandwidth set to 100 Hz while the second filter is disabled by default.

A low-pass filter attenuates the noise in Torque Estimate, but it also reduces the bandwidth of the Torque Estimate which is characterized as a slower response due to the increase in phase lag and damped response. A balance between noise attenuation and bandwidth of the Torque Estimate needs to be taken into account while setting one of the two filters as a low-pass to provide a torque signal that is clean enough for the application but still with sufficient dynamic response.

Follow these steps to configure either Filter 1 or Filter 2 as a low-pass filter.

1. Configure one of the filters as a second-order low-pass and keep the other filter disabled. So, either:
   - Set Torque Estimate Notch 1 Gain = 0 to use the first filter as a low-pass filter.
   - Set Torque Estimate Notch 2 Gain = 0 to use the second filter as a low-pass filter.

   If one of the filters was already configured as a notch filter as described in Configure a Notch Filter, keep the configuration instead of disabling it.
2. Set the Torque Estimate Notch Width of the selected filter to 1.
3. Set the Torque Estimate Notch Frequency of the selected filter to the max value of 2500 Hz.
4. Use Studio 5000 Logix Designer to create a Trend.
5. Add the Torque Estimate attribute of the axis being configured to the Trend.

6. Run the Trend to monitor the Torque Estimate and command motion (for example: an index move using a Motion Axis Move (MAM) instruction or a jog move with a Motion Axis Jog (MAJ) instruction).
7. Progressively reduce the Torque Estimate Notch Frequency until the noise in Torque Estimate is equal or below the desired noise level.

Configure a Notch Filter

Either or both filters shown in Figure 1 can be configured as a notch filter. If more than one frequency needs to be attenuated, both filters can be configured as notch filters in case one of the filters is not already in use.

Follow these steps to configure either Filter 1 or Filter 2 as a notch filter.

1. Set one or both filters as a notch filter. If one of the two filters is already configured as a low-pass filter, set the filter that is available as a notch filter. So, either:
   - Set Torque Estimate Notch 1 Gain = 1 to use the first filter as a notch filter.
   - Set Torque Estimate Notch 2 Gain = 1 to use the second filter as a notch filter.
2. Set the Torque Estimate Notch Width to the default of 0.707. You may also set this parameter to a lower value to attenuate a frequency in a narrower window if necessary (see Table 4).
3. Set the Torque Estimate Notch Depth of the selected filter to 0.
4. Use Studio 5000 Logix Designer to create a Trend.
5. Add the Torque Estimate attribute of the axis being configured to the Trend.
6. Run the Trend and command motion (for example: an index move using an MAM instruction or a jog move with a MAJ instruction).
7. Set the Torque Estimate Notch Frequency to attenuate the noise in Torque Estimate. The notch frequency is the main parameter of a notch filter. Some methods to identify the frequency to set the Torque Estimate Notch Frequency are as follows:
   a. Application frequency: Set the Torque Estimate Notch Frequency to any specific frequency, defined by the application, that needs to be attenuated.
   b. Manual settings: Manually vary the Torque Estimate Notch Frequency value until the noise of the Torque Estimate signal is below the desired noise level. The max value to vary the Torque Estimate Notch Frequency is 2500 Hz. Alternatively, this manual process can be automated with the procedure provided in Appendix A.
   c. Using Tracking Notch from Torque Notch Filters to set VTS filters: Set the Torque Estimate Notch Frequency of VTS to the Torque Notch Filter Frequency Estimate from Tracking Notch as detailed in Using Tracking Notch from Torque Notch Filters to Set VTS Notch Filters. If further insight regarding the impact of the notch filter in the attenuation of noise in Torque Estimate is needed, the method in Appendix B can be used.

Using Tracking Notch from Torque Notch Filters to Set VTS Notch Filters

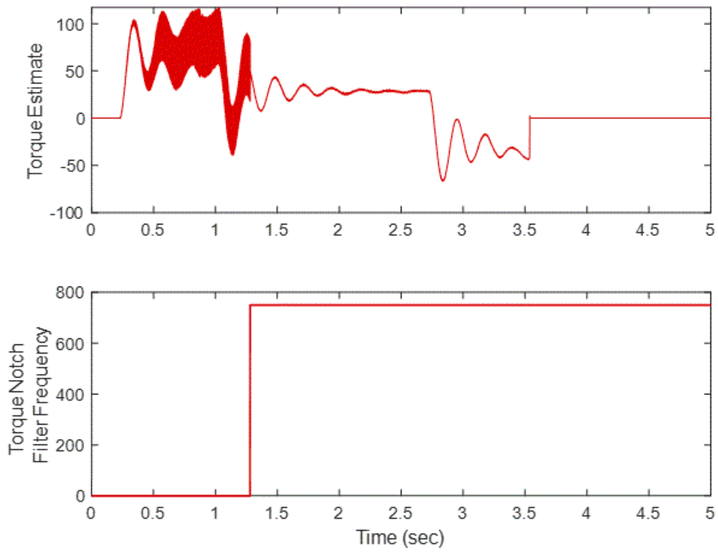
Tracking Notch is a feature to automatically configure the Torque Notch Filters. Tracking Notch can also be used to easily identify the frequencies for the Torque Estimate Notch Filters to attenuate noise in Torque Estimate. See Motion System Tuning Application Techniques, publication MOTION-AT005 for details about Tracking Notch.

Since Tracking Notch can be enabled or disabled by the user, the procedure to configure the Torque Estimate Notch Frequency with Tracking Notch when it is either enabled or disabled is given next.

Tracking Notch Enabled

If Tracking Notch Filter is enabled, the noise in Torque Estimate signal is also attenuated after the Tracking Notch identifies one or more resonant frequencies and sets the Torque Notch Filters. As a result, the use of Filter 1 and Filter 2 as notch filters, shown in Figure 1, are in general not required to attenuate resonant frequencies in Torque Estimate. An example is shown in Figure 4, where the noise in Torque Estimate is attenuated after the Tracking Notch identifies a resonant frequency of 750 Hz, and then sets one of the Torque Notch Filters.

Figure 4 - Torque Estimate Noise Attenuated after Tracking Notch sets one of the four Torque Notch Filters



However, if the Tracking Notch is set to 1 notch filter as shown in Figure 5, for example, and two resonant frequencies are present in the system, the Torque Estimate Notch Frequency of Filter 1 or Filter 2, can be set to the value in Torque Notch Filter 2 Frequency Estimate as, shown in Figure 6 to further attenuate the noise in Torque Estimate.

Figure 5 - Tracking Notch Configuration

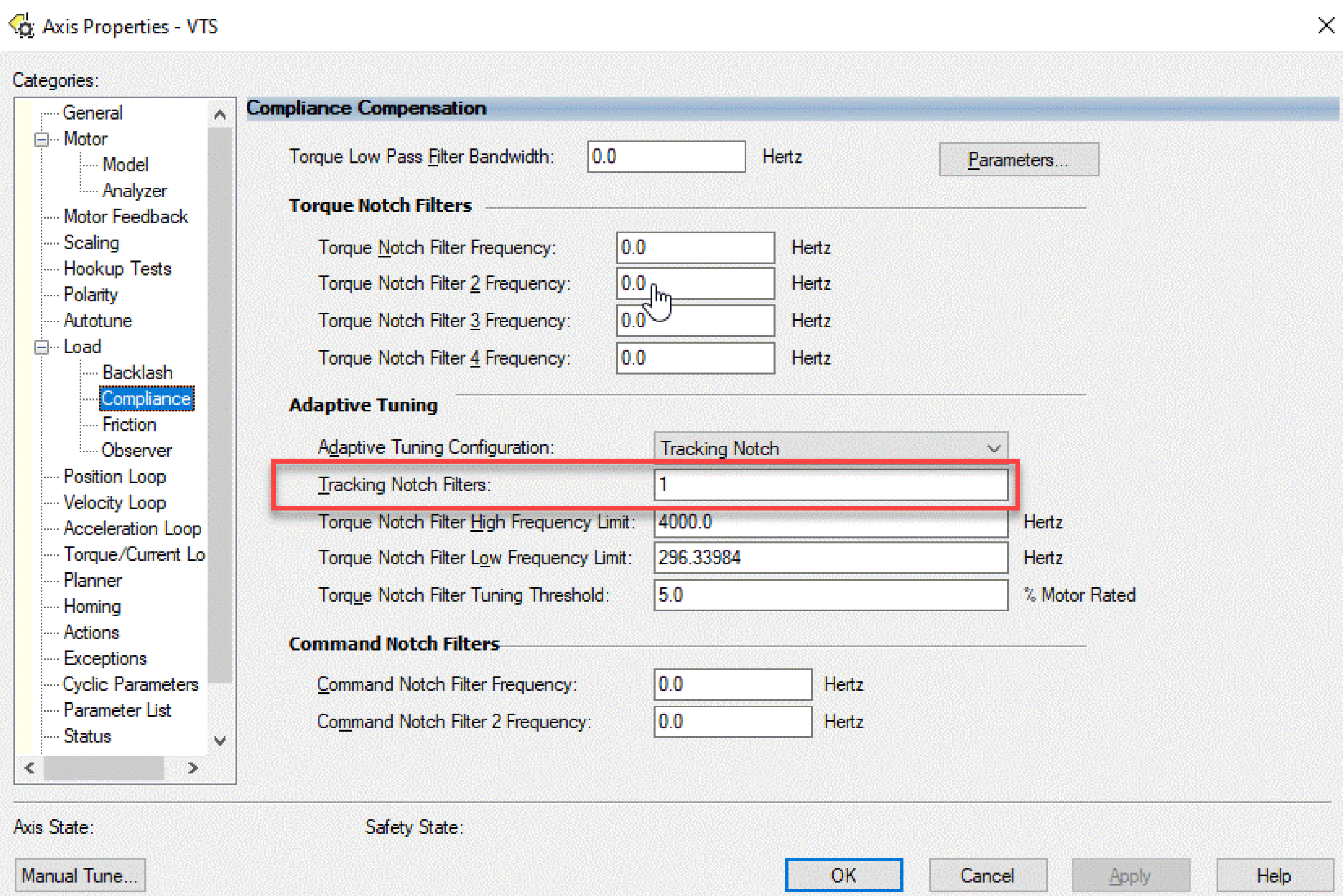
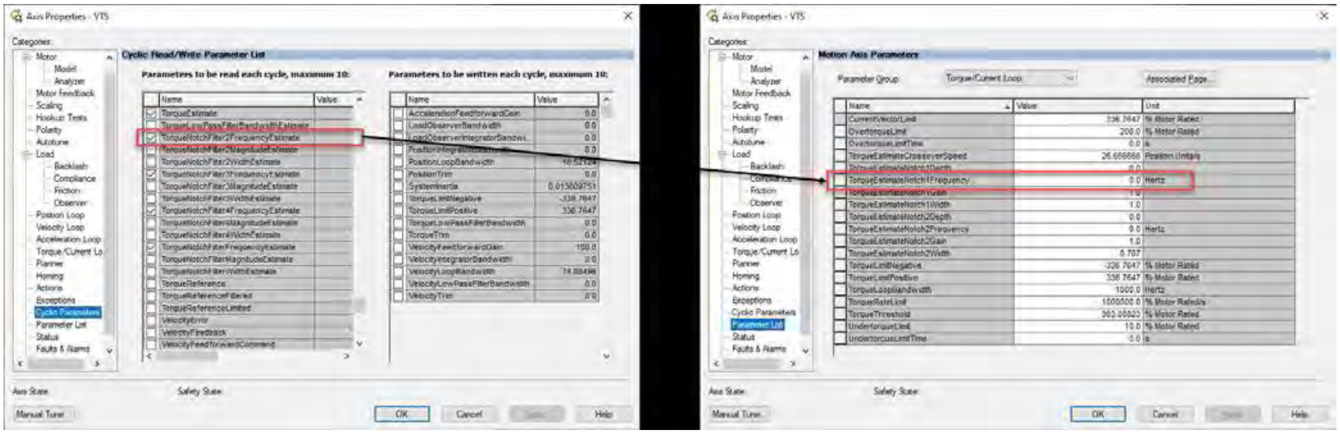


Figure 6 - Setting of VTS Filters with Tracking Notch



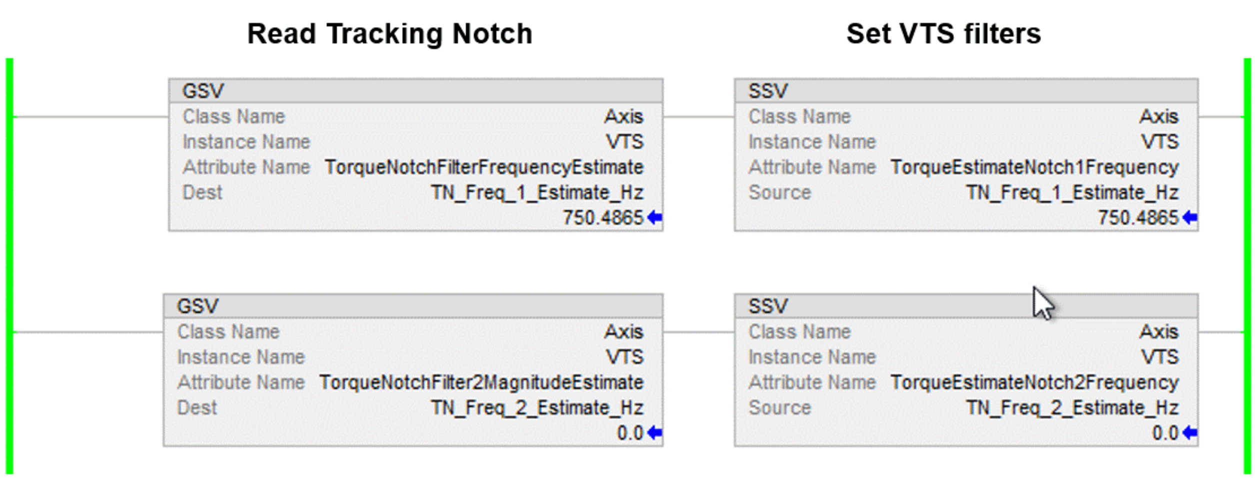
Tracking Notch Disabled

If the Tracking Notch is disabled, the frequencies identified by the Tracking Notch can be used to set the Torque Estimate Notch Frequency of Filter 1 and/or Filter 2 when configured as a notch filter.

After running motion (e.g. an index move with an MAM instruction or a jog move with a MAJ instruction), copy the value from Torque Notch Filter Frequency Estimate to Torque Estimate Notch Frequency of Filter 1 or Filter 2 similarly as shown in Figure 6. If TorqueNotchFilter2FrequencyEstimate also identified a frequency, set TorqueEstimate2NotchFrequency = TorqueNotchFilter2FrequencyEstimate after configuring Filter 2 as a notch filter.

Alternatively, Get System Value (GSV) and SSV instructions can be used as shown in Figure 7 to copy the frequencies identified by Tracking Notch into the frequency of Filter 1 and Filter 2 when configured as notch filters.

Figure 7 - Set VTS Filters Based on Tracking Notch Estimated Frequencies



Applications of Virtual Torque Sensor

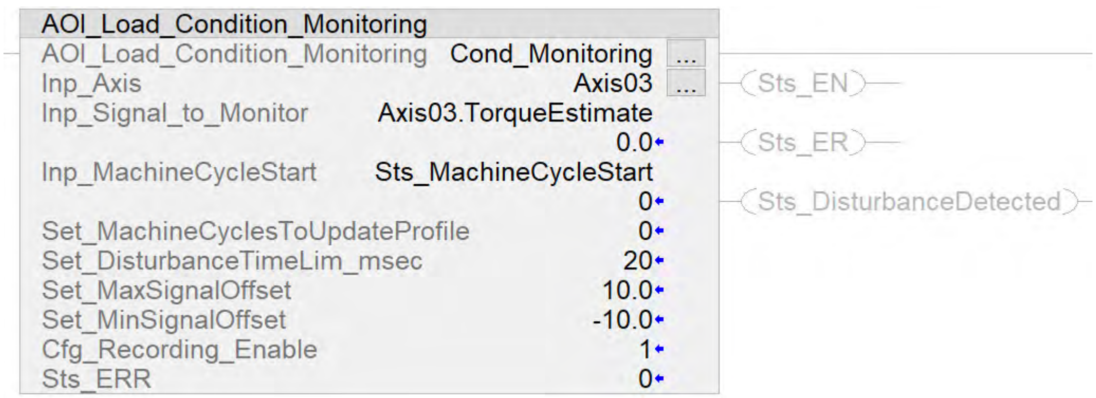
The motor torque estimated via VTS can be used in various applications including:

- **Jam Detection**

  During production, when a product jams in the machine, a sudden change in torque may occur which can be used to detect a product jam. However, since the jam may occur at any moment during a motion profile (including when torque is low), a simple torque threshold monitoring may not be sufficient to detect a jam fast enough, because until torque increases to the threshold value, it may be too late to properly stop motion. Instead, if the torque of a normal machine cycle is stored and continuously compared to the torque that the motor develops while in operation, the deviation between the stored torque and torque during operation can be used to quickly detect product jam.

  This approach is implemented as an AOI (Add-On Instruction) and available in the Sample Code Library under Condition Monitoring for Motion Axis.

Figure 8 - Condition Monitoring



- **Belt Tension Assistant**

  The same AOI used for jam detection can also be used to assist in belt replacement by storing the torque profile before replacing the belt and comparing to the torque profile after replacing the belt. The differences in torque profile indicated by the AOI can be used to adjust the belt tension of the new belt until the differences are considered sufficiently low to assume that the new belt matches the tension of the replaced belt.

- **Mechanical Issue Detection**

  The same AOI used for jam detection can also be used to identify issues with the mechanical system connected to the motor by comparing the torque signal acquired by the AOI while the machine was in a healthy state to the torque signal while the machine is in operation. Mechanical issues that could potentially be detected with this approach include gear tooth fracture or breakage in gearboxes, bearing damage, damaged coupling, damaged ballscrews, and broken blades or worn blades in rotary knives.

- **Gearbox Protection**

  In order to avoid premature failures, the output torque of the gearboxes, needs to stay below the two values defined in the gearbox specifications: Maximum Acceleration Output Torque and Maximum Nominal Output Torque.

  The Torque Estimate can be used to monitor the gearbox limit with respect to the Maximum Acceleration Output Torque by estimating the gearbox output torque:

  Equation 1:

$$\begin{gathered}\text{Gearbox Output Torque } [N \bullet m] = \\ \{ (\text{Torque Estimate}[\%] \times \text{Motor Rated Torque}[N \bullet m] / 100) - \\ (\text{Rotor Inertia } [kg \bullet m^2] + \text{Gearbox Input Inertia } [kg \bullet m^2]) \times \text{Command Acceleration}[rad/s^2] \} \times \\ \text{Gearbox Ratio} \times \text{Gearbox Efficiency}\end{gathered}$$

The comparison between the Gearbox Output Torque x Load Factor and the Maximum Acceleration Torque defines if the gearbox maximum acceleration torque is exceeded. Load Factor is a function of the number of cycles per hour and is provided in the datasheet of gearboxes. Methods to reduce the acceleration torque below the gearbox limit include reducing the production rate or modifying the motion profile.

Similarly, Torque Estimate can also be used monitor the gearbox limit with respect to the Maximum Nominal Output Torque by estimating the average gearbox output torque.

Equation 2:

$$Average\ Gearbox\ Output\ Torque\ [N.m] = \sqrt[3]{\frac{\sum_{k=1}^{k=K} |n_{2_k}| \times dt_k \times |T_{2_k}|^3}{\sum_{k=1}^{k=K} |n_{2_k}| \times dt_k}}$$

Where, n_2 is the speed at the output of the gearbox in rad/s which is the motor speed/gearbox ratio, dt is the sampling time in seconds, T_2 is the Gearbox Output Torque in *N•m* (see Equation 1 in Gearbox Protection), k is the index, and K is the number of samples used in this first-in first-out calculation.

The comparison between the calculated Average Gearbox Output Torque and the Maximum Nominal Output Torque determines if the gearbox utilization was exceeded.

Thus, a warning that the gearbox torque limits were exceeded could be generated when:

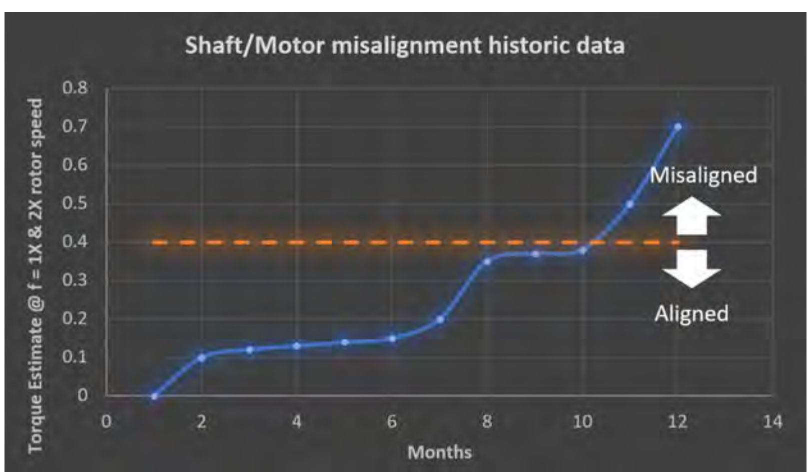
Equation 3:

Gearbox Output Torque [N•m] x Load Factor > Maximum Acceleration Output Torque [N•m]
or
Average Gearbox Output Torque [N•m]) > Maximum Nominal Output Torque [N•m]

- **Motor/load Misalignment Monitoring**

  The frequency spectrum response of Torque Estimate can be used to monitor shaft misalignment between the motor and the load. The progression of shaft misalignment can be identified by monitoring the historical values of magnitude of the frequency component of Torque Estimate at the frequency of the rotor speed and twice the rotor speed.

Figure 9 - Example of Motor/Load Misalignment Monitoring



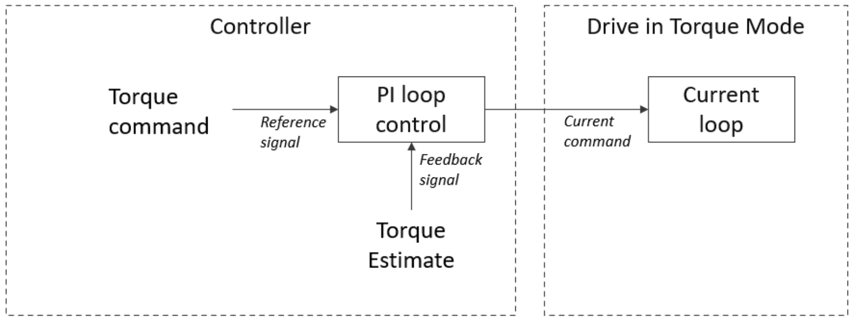
- **Machine Process Decision Assistant**

  The Torque Estimate can be used to monitor the load torque or load forces (calculated from Torque Estimate and mechanical system data) to make decisions about the settings of the axis under monitoring or other axes on the machine.

- **Torque Loop**

  The Torque Estimate can be used as the feedback signal for a torque loop control implemented in the controller as shown in Figure 10. The loop update and bandwidth are limited by the coarse update period.

Figure 10 - Torque Loop Control



See Knowledgebase Article, Virtual Torque Sensor for Kinetix Drives: Documentations and Resources, for a list of documentations and videos of applications with Virtual Torque Sensor.

Automated Frequency Search to Tune a Notch Filter

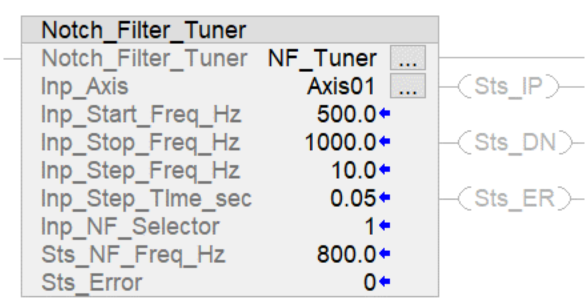
Use the Notch Filter Tuner AOI (Add-On Instruction) available in the Sample Code Library to identify the Torque Estimate Notch Frequency that most attenuates the noise in Torque Estimate. This AOI automatically varies the Torque Estimate Notch Frequency of the selected filter (1 or 2) between a user-defined frequency range which allows to identify the notch filter frequency value that most attenuate the noise in Torque Estimate. See Sample Code Library article Notch Filter Tuner AOI for more details. The procedure to use this AOI is as follows:

1. Download the Notch Filter Tuner from the Sample Code Library and import it into the controller program.
2. Set the start (Inp_Start_Freq_Hz) and stop (Inp_Stop_Freq_Hz) frequency to the desired range of frequencies to search for the frequency that most attenuate noise in Torque Estimate. A range between 200 Hz…1000 Hz is generally sufficient. The maximum stop frequency is 2500 Hz. See Figure 11.
3. Set the Inp_Step_Freq_Hz to the step change between the frequencies to be tested. For the example provided in Figure 11 with a step of 10 Hz, the test frequencies are 500 Hz, 510 Hz, 520 Hz, and so forth until 1000 Hz is reached. For a first pass, a step of 10 Hz is generally appropriate.
4. Set the Inp_Step_Time_sec to the time that the drive should keep the notch filter set for each test frequency. In general, 50 ms is sufficient, or at least 10 times the coarse update period. For the example provided in Figure 11, the Torque Estimate Notch 1 Frequency would stay at 500 Hz for 50 ms, at 510 Hz for 50 ms, and so forth until the AOI reaches the frequency of 1000 Hz.
5. Set the Inp_NF_Selector to 1 or 2 to select either Filter 1 or Filter 2. See Figure 1.
6. Create a trend in Studio 5000 Logix Designer® with two tags (see Figure 12):
   a. Torque Estimate from the axis that is being configured
   b. Sts_NF_Freq_Hz from the AOI assigned to the axis that is being configured
7. Start the Trend in the Logix Designer application.
8. Command motion (for example: an index move with a Motion Axis Move (MAM) instruction or a jog move with a Motion Axis Jog (MAJ) instruction) for the amount of time that the AOI takes to complete the test which is:

$$Test\ Time\ [sec] = \frac{(Inp\_Stop\_Freq\_Hz\ - Inp\_Start\_Freq\_Hz)}{Inp\_Step\_Freq\_Hz} Inp\_Step\_Time\_sec$$

9. Enable the AOI at the same time that the motion starts.
10. This procedure can be repeated in two steps by setting the frequency range wider first, and then repeating the test for a narrower frequency range (defined by Inp_Start_Freq_Hz and Inp_Stop_Freq_Hz) and a smaller step change (Inp_Step_Freq_Hz) to more accurately identify the frequency that most attenuates the noise in Torque Estimate to minimize the time to perform the test. See Figure 12 and Figure 13.
11. Set the Torque Estimate Notch Frequency to the frequency value in the trend that most attenuates the noise in Torque Estimate.

Figure 11 - Notch Filer Tuner AOI



An example of this procedure is shown in Figure 12 and Figure 13. A first test from 500 Hz…1000 Hz with a step of 10 Hz every 50 ms was performed as shown in Figure 12. The settings for this first test are as shown in Figure 11. As shown in Figure 12, the Torque Estimate Notch Frequency value that most attenuated the noise in Torque Estimate was in the range from 740 Hz…770 Hz. This test was repeated for a frequency range from 700 Hz...800 Hz with steps of 2 Hz and the results are shown in Figure 13. From this trend, a value around 750 Hz for the Torque Estimate Notch Frequency provided the most attenuation of the noise in Torque Estimate.

Figure 12 - First Pass from 500 Hz to 1000 Hz with 10 Hz Steps

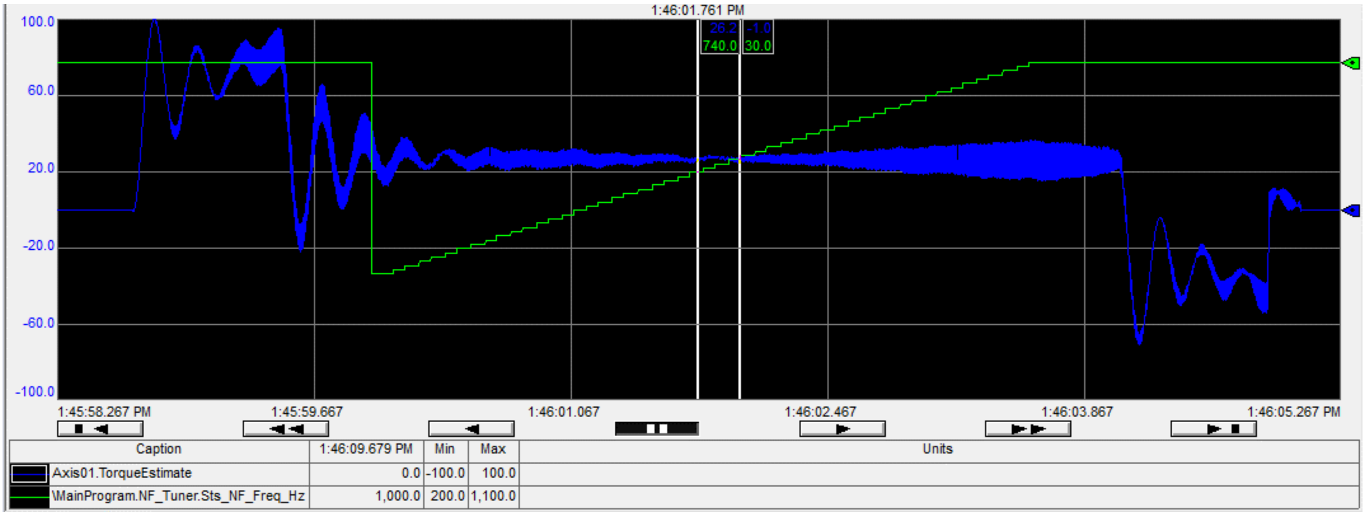
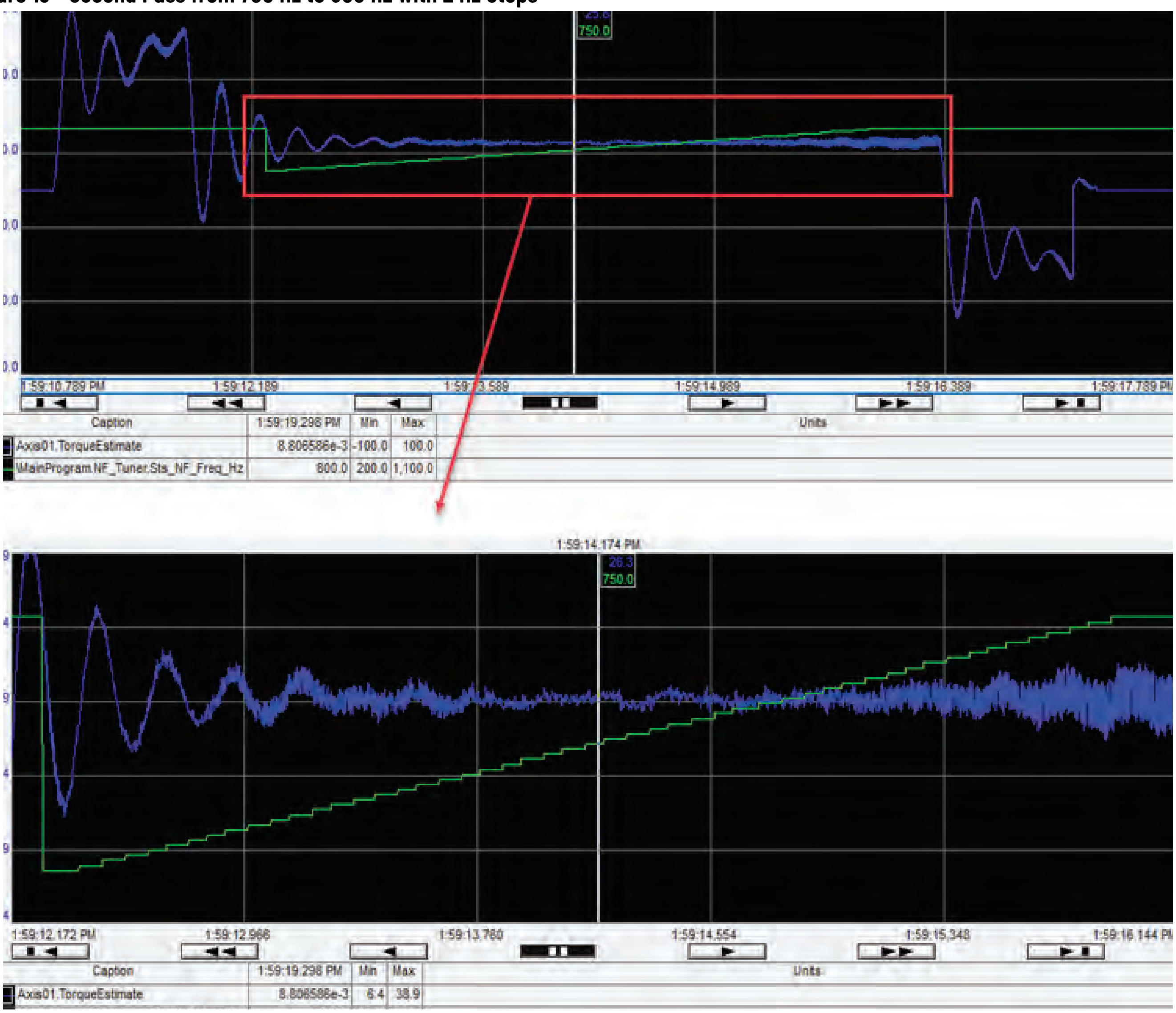


Figure 13 - Second Pass from 700 Hz to 800 Hz with 2 Hz Steps



Frequency Response of Torque Estimate to Tune a Notch Filter

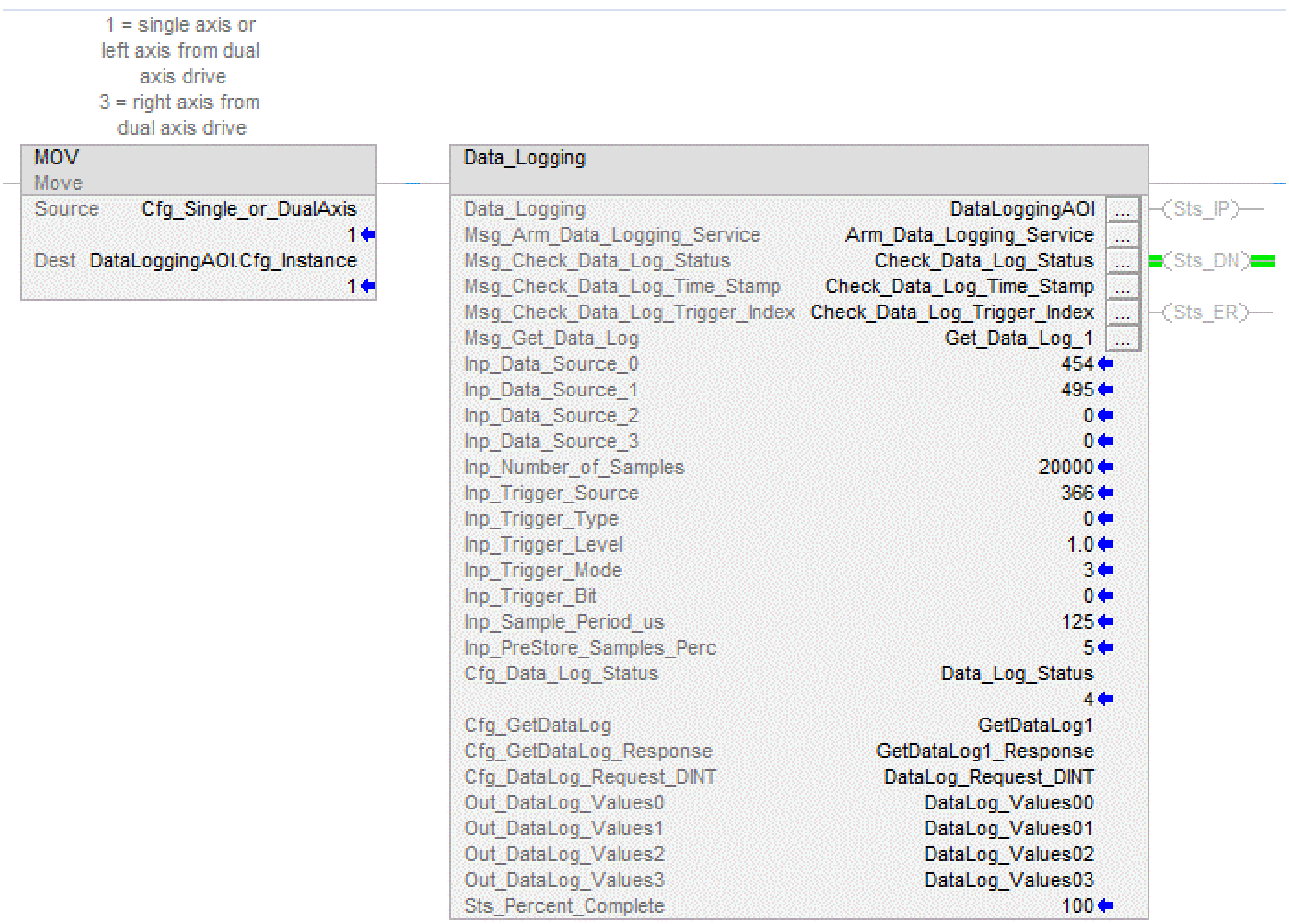
The Torque Estimate Notch Frequency value to attenuate the noise in the Torque Estimate can be accurately identified from the frequency spectrum that is calculated from the Torque Estimate data captured at the drive update rate.

Data can be captured at the drive update rate with a drive feature called Data Logging. This feature can be easily configured, trigged, and used to retrieve data from the drive into the controller with the Data Logging AOI, which is available for download as a Knowledgebase Article, Kinetix 5300, 5500, and 5700 Data Logging feature for High Speed data collection. Refer to Figure 14.

Follow this procedure to capture data at the drive update rate with Data Logging in order to compute the frequency response of the Torque Estimate and identify the frequency to set the Torque Estimate Notch Frequency:

1. Import the AOI into Studio 5000 Logix Designer®.
2. Follow the AOI documentation to configure the AOI. See also the sample ACD file and documentation available in the Knowledgebase article.
3. Set one of the Data Sources to 495 which is the Attribute ID of Torque Estimate.
4. Set the AOI as shown in Figure 14.

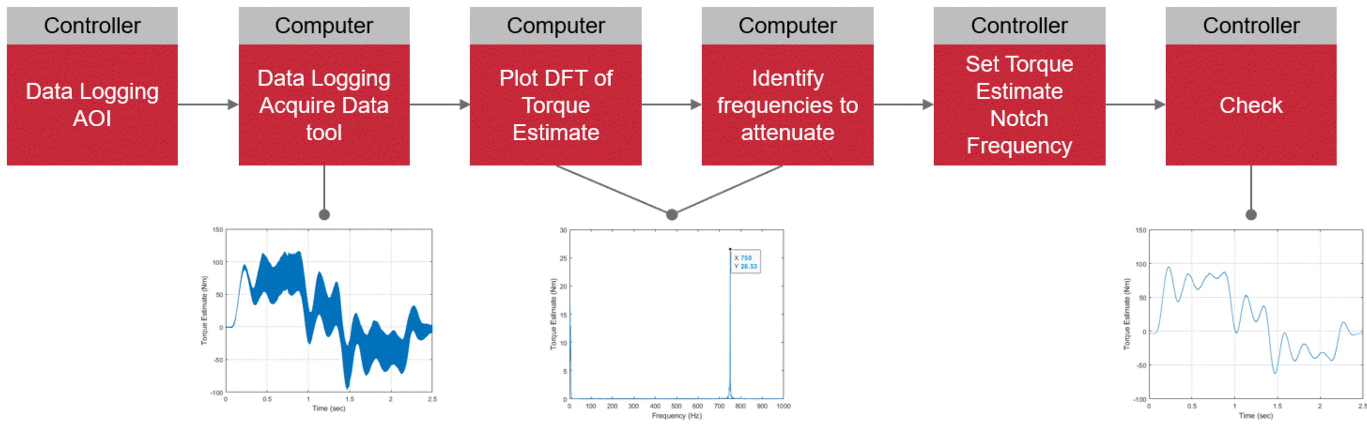
Figure 14 - Data Logging AOI



5. Run motion and enable the Data Logging AOI at the same time.
6. After the AOI finishes reading data from the drive, use the DataLoggingAcquireData - AOI - R03.xlsm tool to read the data from the controller. This tool is available in the Knowledgebase article [Kinetix 5300, 5500 and 5700 Data Logging feature for High Speed data collection.]
7. Calculate the Fast Fourier Transform (FFT) of the Torque Estimate.
8. Set the Torque Estimate Notch Frequency to the frequency with the highest magnitude in the frequency spectrum that is not a frequency from the motion profile.

This procedure is summarized in Figure 15.

Figure 15 - Procedure to Computer Frequency Response of Torque Estimate.2



Additional Resources

These documents contain additional information concerning related products from Rockwell Automation.

Resource	Description
Kinetix 5700 Servo Drives User Manual, publication 2198-UM002	Provides information on installing, configuring, startup, troubleshooting, and applications for your Kinetix 5700 servo drive system.
Kinetix 5300 Servo Drives User Manual, publication 2198-UM005	Provides information on installing, configuring, startup, troubleshooting, and applications for your Kinetix 5300 servo drive system.
Motion System Tuning, publication MOTION-AT005	Provides information on tuning a Kinetix drive system.
Kinetix Tuningless Quick Start Guide, publication MOTION-QS001	Provides information to quickly tune Kinetix drives.
Product Certifications website, rok.auto/certifications.	Provides declarations of conformity, certificates, and other certification details.
Kinetix 5500 and 5700 Data Logging feature for High Speed data collection, ID: QA34226	Knowledgebase Article that explains how the data logging feature works on Kinetix 5500 and Kinetix 5700 drives.
Virtual Torque Sensor for Kinetix Drives: Documentations and Resources, ID IN38561	Knowledgebase Article that contains a list of documentation and videos about Virtual Torque Sensor (VTS) and VTS applications.
Condition Monitoring for Motion Axis, ID 101051	Sample Code Library Add-on Instruction to detect anomalies in mechanical systems.
Notch Filter Tuner AOI, ID 101058	Sample Code Library Add-on Instruction to help in the identification of the frequency for the Torque Estimate Notch Frequency.
Integrated Motion on the EtherNet/IP Network: Configuration and Startup, publication MOTION-UM003	Use this manual to configure an integrated motion on the EtherNet/IP™ network application and to start up your motion solution with a Logix controller-based system.
Integrated Motion on the EtherNet/IP Network, publication MOTION-RM003	Provides a programmer with details about the Integrated Motion on the EtherNet/IP network Control Modes, Control Methods, and AXIS_CIP_DRIVE Attributes.

You can view or download publications at rok.auto/literature.

Rockwell Automation Support

Use these resources to access support information.

Technical Support Center	Find help with how-to videos, FAQs, chat, user forums, and product notification updates.	rok.auto/support
Knowledgebase	Access Knowledgebase articles.	rok.auto/knowledgebase
Local Technical Support Phone Numbers	Locate the telephone number for your country.	rok.auto/phonesupport
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

Your comments help us serve your documentation needs better. If you have any suggestions on how to improve our content, complete the form at rok.auto/docfeedback.

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

Rockwell Otomasyon Ticaret A.Ş. Kar Plaza İş Merkezi E Blok Kat:6 34752, İçerenköy, İstanbul, Tel: +90 (216) 5698400 EEE Yönetmeliğine Uygundur

Connect with us.

rockwellautomation.com — expanding **human possibility**™

AMERICAS: Rockwell Automation, 1201 South Second Street, Milwaukee, WI 53204-2496 USA, Tel: (1) 414.382.2000, Fax: (1) 414.382.4444
EUROPE/MIDDLE EAST/AFRICA: Rockwell Automation NV, Pegasus Park, De Kleetlaan 12a, 1831 Diegem, Belgium, Tel: (32) 2 663 0600, Fax: (32) 2 663 0640
ASIA PACIFIC: Rockwell Automation, Level 14, Core F, Cyberport 3, 100 Cyberport Road, Hong Kong, Tel: (852) 2887 4788, Fax: (852) 2508 1846

Publication 2198-AT003A-EN-P - September 2020