AKD™

AKD™ Positioner Training Manual

Rev 4.2.0

This training module is intended to provide a full understanding of AKD. This manual will help the user to become familiar with setting up an AKD. This workbook is the prerequisite to the AKD BASIC training manual.

Material is subject to change based on firmware and WorkBench™ design development.

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Introduction to AKD™ Advanced Kollmorgen Drive™

The AKD Servo Drive is designed with the end user in mind. The AKD provides to the customer the fastest current and velocity loops on the market. The WorkBench graphical user interface, or GUI, makes setup fast and intuitive.

Kollmorgen servomotors with intelligent feedback devices become Plug & Play, removing the need for any motor setup. Tuning can be completed using either the Automatic mode or Manual mode. The Bode Tool can provide important information about the system to which the drive is connected.

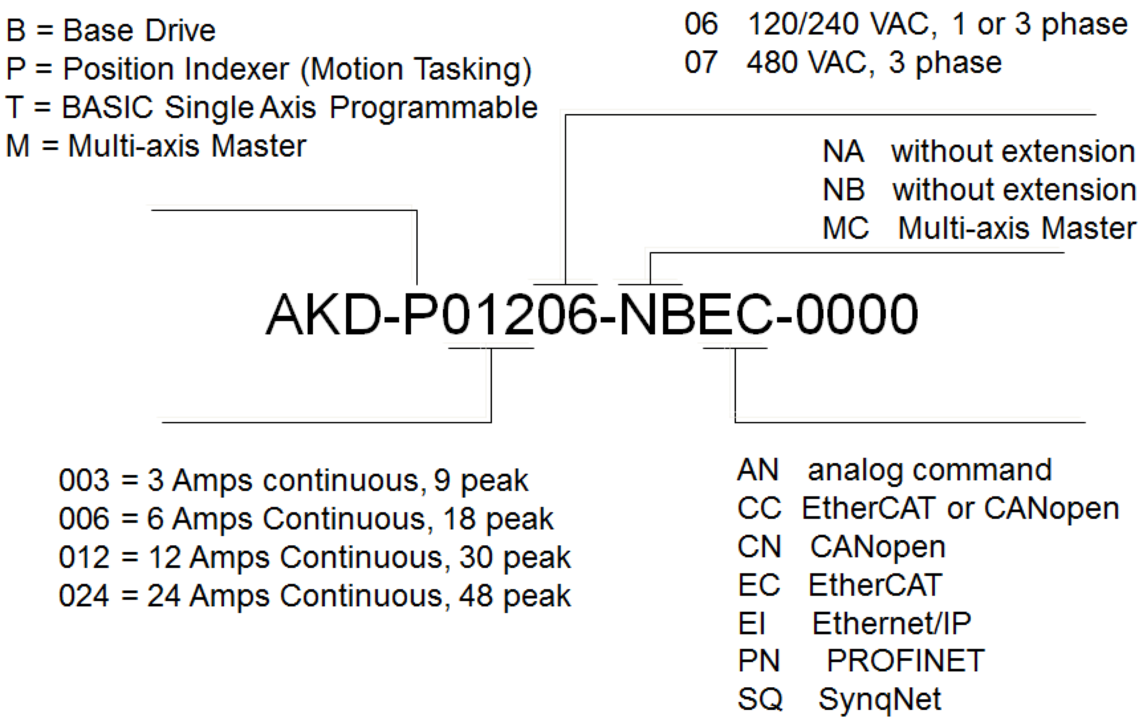
Features of AKD

- Ease of Use
- Plug & Play motor combinations
- Advance Tuning
- Intuitive Graphical User Interface
- Fastest Current and Velocity Loop on the market
- Versatile Connectivity
- Robust Design

Benefits of AKD

- Fast Setup
- Highest Throughput
- Reduced Down Time

Part Number Break Down



Support Materials Available

- User Guide (in WorkBench Help)
- WorkBench & firmware
- Sample Motion Task & Setup

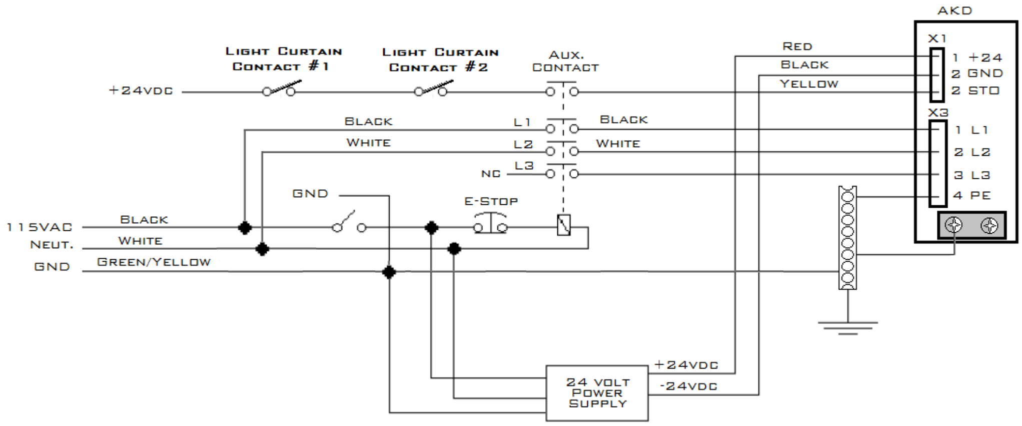
Wiring the Drive for Training

The AKD Servo Drive is mounted on the base plate and wired to 115vac for training. The following schematic is provided since the base plate is prewired for simulation of an electrical cabinet.

Power Connections

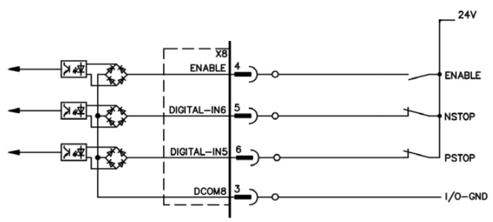
Include on the base plate are:

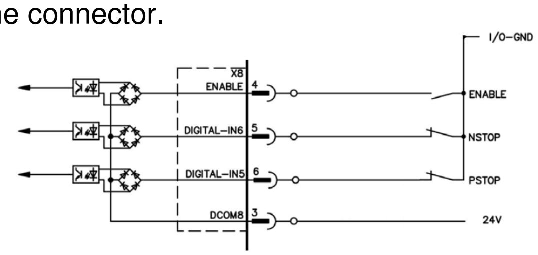
- 115vac Circuit Breaker
- 24vdc Power Supply
- Emergency Stop Button
- Power Contactor
- Auxiliary Contacts for STO
- Terminal Strip for easy connection
- Ground Bar



Note: Not included on the base plate are the Light Curtain Contacts. They have been added to show where the contacts could be added in a real world application.

The I/O connections are made using the manual control I/O box, part number: AKD-CONTROLBOX-A. The AKD I/O is Optically Isolated and can be configured for either Sinking or Sourcing, but not both on the same connector.





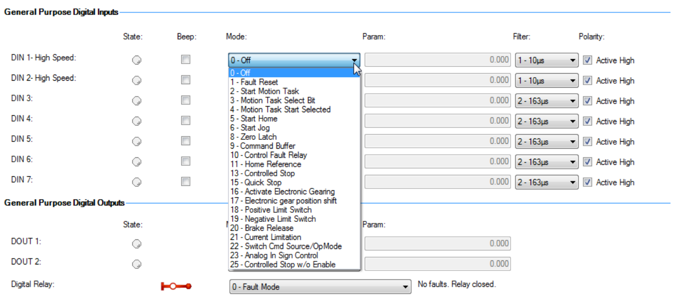
Input is sourcing – Drive is sinking   Input is sinking – Drive is sourcing

Note: X7 & X8 have individual DC Commons that must be wired up. These DC Commons are not connected internally. This allows X7 & X8 to be connected as either sourcing or sinking independently of each other. For example, X7 can be sourcing and X8 can be sinking. But all the connections on X7 & X8 must be connected in the same configuration.

Digital Inputs and Outputs

The Digital I/O connections are made on connectors X7 & X8. Once the connections are properly made, they can be configured in WorkBench. Digital Inputs 1 & 2 both are high speed inputs with update rates of 2µs. Digital Inputs 3 to 7 are standard programmable inputs with update rates of 250 µs.

The function of the input can be programmed in WorkBench and selecting one of the twenty-one available modes. Each input has a drop down box with the available mode.



The mode selected will depend on the application requirements. Keep in mind End Of Travel limits are, in most cases, Normally Closed, and Home Switches are Normally Open.

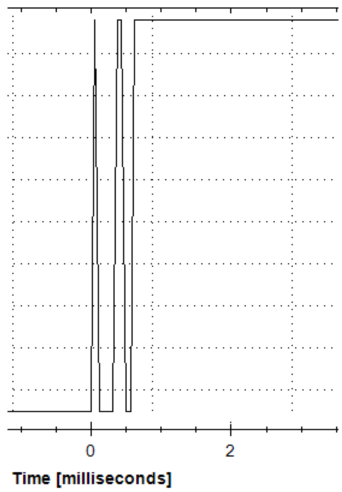
All of the inputs can have Filters add, or the Polarity changed. Adding filters can be very helpful when the input is from a mechanical switch that may bounce when closing or opening.

Setting the filter to 0 – Off will allow all inputs to be detected. The image to the right is a scope plot of Digital Input 1 with filters off. The input is coming from a snap action switch. The bounce of the switch is clearly visible in the scope plot.

A bouncing input can trigger more than one move. Adding a filter can insure the trigger will be acknowledged only once.

The available filters are:

- 0 – Off (detects all inputs ≥40ns wide)
- 1 - 10µs (detects all inputs ≥10.24µs wide)
- 2 – 162µs (detects all inputs ≥163µs wide)
- 3 – 2.62ms (detects all inputs ≥2.62ms wide)



Digital Input with filters off.

Polarity allows the input to be changed from Active High to Active Low. Polarity can be changed in Workbench by clicking Polarity, ☑ Active High, or by setting the parameter. The parameter is, DINx.INV, and will be set as follows.

- 0 – Input is Active High
- 1 – Input is Active Low

CAUTION: Changing the Polarity with the drive enabled can cause unexpected motion.

WorkBench - AKD™ Positioner

Overview

The Advanced Kollmorgen Drive is the most advanced servo drive on the market. The WorkBench software used to set-up and program the drive is an intuitive graphical user interface. The power of the AKD comes for its high level features such as:

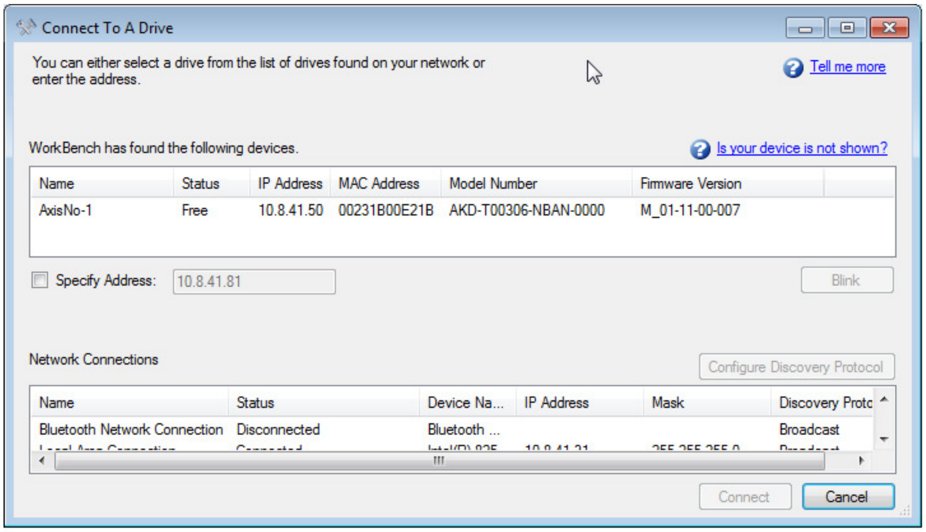
- Plug-and-Play compatibility with Kollmorgen motors
- Digital Signal Processor Control
- Optically Isolated I/O
- Highest Current Loop & Velocity Loop Bandwidth
- Fastest Digital Current Loop on the market
- Wide Feedback Range
- Multiple Bus choices

The AKD is a powerful, yet easy to set-up and use, digital servo drive. Its compact design makes it the industry leader in power density.

Connect to the AKD Drive

To communicate the AKD Servo Drive, the WorkBench graphical user interface is provided. The most recent released version can be found at: **www.kollmorgen.com**. The current versions of Workbench are compatible with the AKD and AKD BASIC.

Open WorkBench™.



IP Address

In order to use the AKD, you must be able to communicate with the device using WorkBench and an Ethernet connection. The AKD uses TCP/IP. Both the AKD and the PC must connect through this standard in order to communicate.

Automatic (Dynamic) IP Address

The IP Address for each drive can be set automatically, or dynamically. This is using the Dynamic Host Configuration Protocol (DHCP). To set the drive to Automatic IP Address set switches S1 and S2 to 0. Either power the drive up or cycle power.

The drive will display an I-P on the display followed by the address. This address can change each time the logic power is cycled.

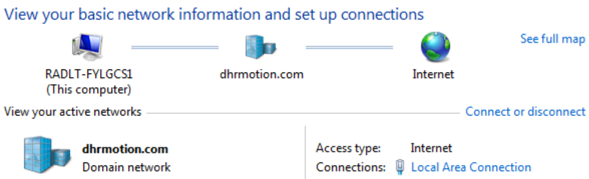
Static IP Address

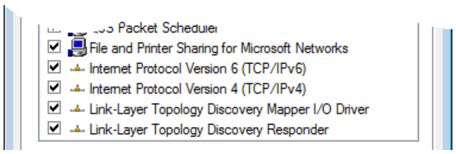
A Static (fixed) IP Address can be set using rotary switches S1 and S2. The IP address for the drive will be set to 192.168.0**x1x2.** The last two numbers, x1 and x2, are set by S1 and S2.

Example:

We want to set the drive address to reflect its location in the system. This drive is Axis No. 15.
S1 is set to 1 & S2 is set to 5
The IP address of the drive is now: 192.168.015

For your computer to see the drive it must be setup in the same domain. To set your computer up, go into your control panel. Here you will find either Local Are Connection or Network and Sharing Center. If it is Network and Sharing Center enter this to find Local Area Connection. Note that your screen may look differently depending on your version of Windows.





In the Local Area Connection click, on Properties then scroll down to TCP/IP version 4 and click on Properties again. Set Use the following IP address and enter:

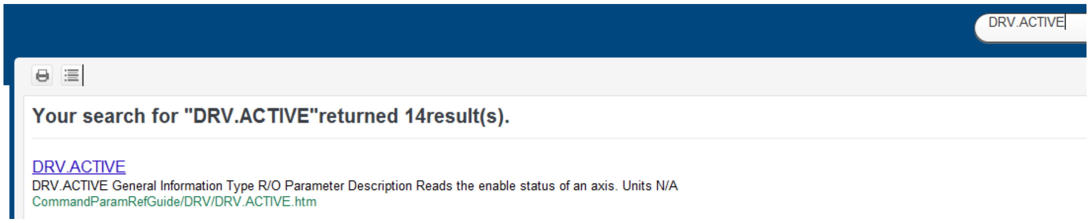
IP Address: 192.168.0.100
Subnet mask: 255.255.255.0

Then click OK.

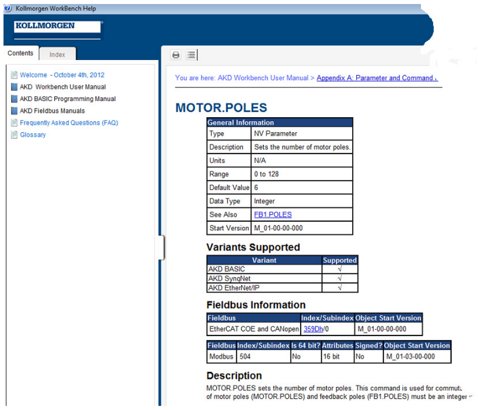
At this point the drives IP Address will appear in the screen and the PC can connect to drive. This address will not change until you decide to make a change.

WorkBench Help

Within WorkBench is provided quick access to the help screens. These can be accessed using the Help tab, or the F1 key. If the Help tab is used the search screen within Help will allow you search on a specific topic. In the example a search of DRV.ACTIVE was made returning 14 results.

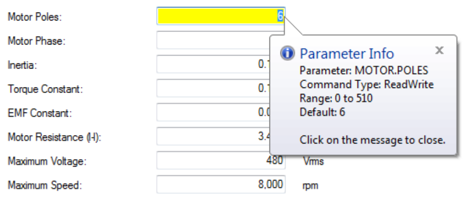


Using the F1 key can take the user to a specific section by clicking on the screen, or within a specific parameter to narrow the search. For example, from the Motor screen and clicking in the Motor Poles then F1 brings up the Help screen specific to MOTOR.POLES, the parameter name.



At this point all the general information about this parameter is displayed. Some of the important information displayed is Type of parameter, Units, Range, and Data Type. Also include is the Variants Supported which is helpful if the parameter is to be changed in other drive types. The Fieldbus Information provides the format and for this parameter in EtherCAT COE, CANopen, and Modbus. A detailed description of the parameter is also provided as well as Related Topics.

Another helpful feature is using the Right Click in the parameter box. A drop down box will appear in which is the selection, "Parameter Info" is available. When this is click a box with a brief description about parameter will appear. At times this is enough information to help complete the current setup task.



Drive Setup Screens

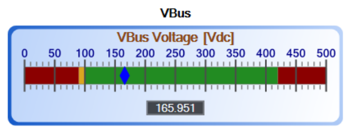
Drive Overview

Settings

- Motor
- Feedback 1
- Feedback 2
- Brake
- Units
- Modulo
- Limits
- Home

Power

The Power screen allows the bus voltage to be monitored, the DC-bus Over-Voltage threshold, DC-bus Under-Voltage threshold, Under-Voltage Fault Mode, and the Operating voltage.



Opmode/Source/Enabled/Running

DRV.OPMODE

The AKD™ servo drive has three operation modes in which it can function. The operation mode, or DRV.OPMODE, of the drive is selected for the application in which the drive is being used. The “Opmode” ranges are 0 to 2.

Mode	Description
0	Current or Torque mode
1	Velocity mode
2	Position mode

The display is indicating that the drive is in position mode and not enabled.

The display indicates that the drive is in position mode and the drive is enabled and active.

DRV.CMDSOURCE

The Command Source sets the method with which the drive will be communicated. During setup of the drive the command source is usually set to 0 for Service mode.

Value	Description
0	Service/TCP/IP
1	Fieldbus
2	Electronic Gearing
3	Analog
5	Program

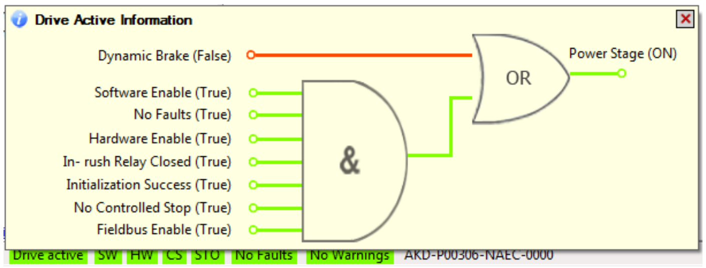
DRV.CMDSOURCE 5 is only available in the AKD BASIC servo drive and is used in the programming mode.

The command source can be changed from the Workbench setup screen, or from the terminal screen.

⚠ WARNING If the DRV.CMDSOURCE is changed in the terminal screen while the drive is enabled the system can experience a step change in command. This can result in unexpected motion.

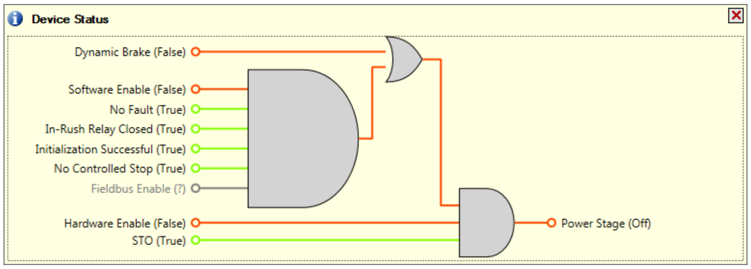
The AKD™ servo drive has to two states when operating. The drive can be enabled or disabled. This is displayed by two LED's located on the front of the drive, and in GUI.

There times that the drive can be enabled but not active. For the drive to be active both the Hardwar enable, HW, and Software enable, SW, must be true, and no faults can have occurred.



The diagram above is the Boolean representation for DRV.ACTIVE to be true. There are no faults and the Software Enable (SW) and Hardware Enable (HW) are true.

Below the DRV.ACTIVE is false and the Power Stage is off. Missing are the Software Enable (SW) and Hardware Enable (HW).



Units / Terminal / Watch window / Scope Tool

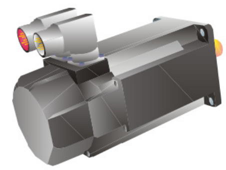
Units

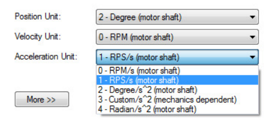

The Units screen is used to set the three primary drive parameters of acceleration, velocity and position into user defined application specific units. This will allow the user to work in clear understandable units. Motion Task will reflect the units as they are established in this section.

For a motor only we can still set the units to our desired values.

In this example the position units are set to degrees of the motor shaft, velocity is in RPM (Revolutions Per Minute) of the motor shaft, and acceleration is being set to RPS/s (Revolutions Per Second per Second).

The range of available units allows the system to duplicate any mechanical scenario found in industry.

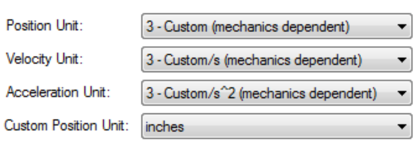




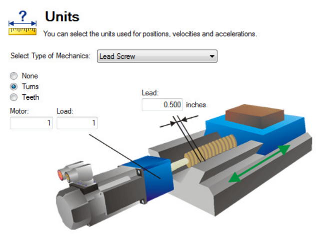
For a motor connected to a lead/ball screw with a lead of 0.5 inches/revolution of the screw, we can set up our units as follow.

In our example the motor is connected to the screw directly. The input has be set to turns to show that this can be expressed as a turns 1 to 1.

The Lead is set to 0.5"/rev of the motor.



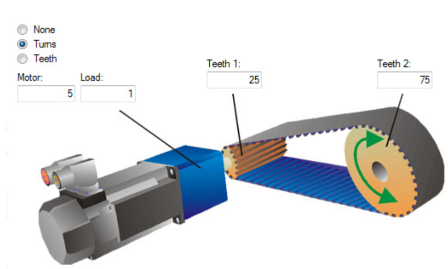
Velocity will be in Inches/second, and acceleration will be in Inches/second/second.



Position units are set the mechanics of the device. Since our lead screw was defined in inches, the position will be provided in inches as well.   Also velocity and acceleration will be mechanically dependent.

Workbench provides many examples of mechanical devices. Each one has a pictorial of the device to assist the operator to correctly enter the information.

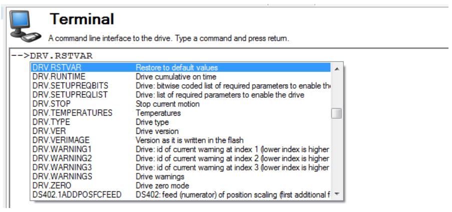
The gear ratios are entered the same way for each unit. Either as none, Turns, or Teeth.



Terminal

Terminal Screen allows parameter or command to be check and entered directly from the drive and to the drive. In most training sessions the terminal screen will be the first stop. From here the drive can be set back to factory defaults.

Note: It is important to make sure you back up the parameter files before resetting the drive as all values will be overwritten.

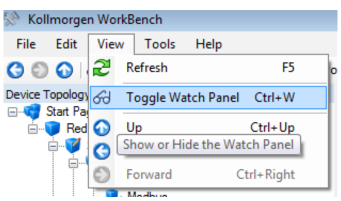


DRV.RSTVAR will restore the drive to its default values. As you begin typing the parameter into the terminal screen it will begin to auto fill. To the right will be a short explanation of the parameter or command.

F1 can be used at any time in any screen. This will be the fast way to the help section of Workbench. While in the terminal screen hitting F1 will take you the section on the Terminal Screen.

Watch Window

The watch window allows selected parameters to be view in real time such as the VL.FB, or the velocity feedback of the motor. The watch window can be turn on in three different ways. The first is from the View tab at the top-left of Workbench.

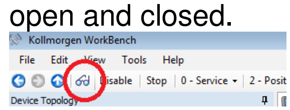


From the tree:

View-

- Toggle Watch Pane

Ctrl +W will open and close the watch window. Or the Icon of the glasses can be clicked to alternate between open and closed.



At the bottom of Workbench will appear the Watch Window. In the example below we are monitoring Position Feedback (PL.FB), Current Feedback (IL.FB), Velocity Feedback (VL.FB), and the state of Digital Input 1 (DIN1.STATE).

Watch

Enable	Device	Parameter	Value	Units
☑	Red (Online)	VL.FB - Velocity feedback	0.351	rpm
☑	Red (Online)	PL.FB - Position feedback	-110.855	deg
☑	Yellow (Online)*	VL.FB - Velocity feedback	0.000	rpm
☑	Yellow (Online)*	PL.FB - Position feedback	12	inches

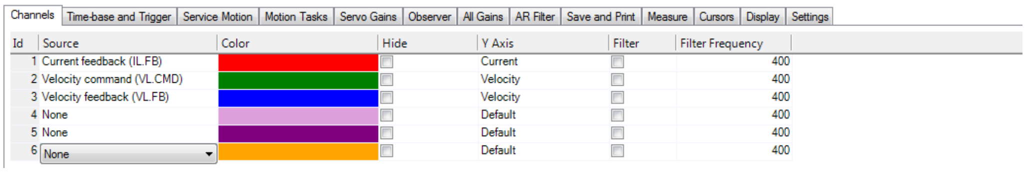
If more than one drive is connected to Workbench Device can be setup for additional axis and different Parameters can be set for each. This provides a simple solution to monitor the different elements of motion.

While the watch window is providing the parameter information in real time, it is not recorded and cannot be played back or viewed at a later time.

Scope Tool

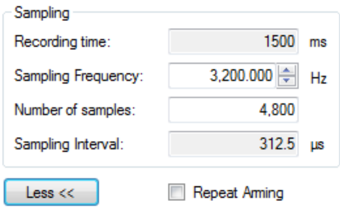
 The Scope tool allows the user to collect and view six channels of data from the drive. Using the trigger mode will allow data to be collect at the same points in a move when repeated.

In the Scope Tool, Channels allows the selection of parameters to be monitored, displayed, and saved for later recall. Parameters can be selected from the Source section. Clicking in the box will bring up a list of parameters. Below we see the default parameters: Current Feedback (IL.FB), Velocity Command (VL.CMD), and Velocity Feedback (VL.FB).

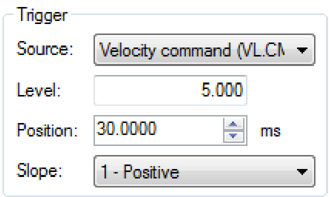


Clicking in the Source section will pull up a list of standard parameters that can be select. Not all the parameters available are on the list so an <User Defined> parameter is available.

Time-base and Trigger allow the Recording time and Trigger to be setup. The Recording time can be set by simply adjusting the time in milliseconds. If, however, there is a need to increase the number of samples within a given time the More >> button can be click to provide access to the Sampling frequency and Number of samples.



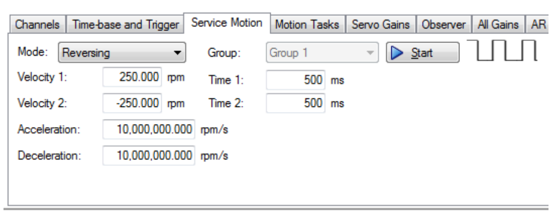
The Trigger is used to begin the recording at the same place in the move every time. The most common Trigger Type is VL.CMD. Since a position move will generate a velocity command, VL.CMD, it is a very good trigger point. The level is set slightly above the ambient velocity command, or that which holds position.



The slope indicates the direction of the command off which the trigger will occur. If our first move is positive this will be set to 1-Positive, and if negative it will be set to 0-Negative. Position is the amount of record time that will be kept in advance of the trigger. When the system is armed it basically recording data at that point and will keep the amount of data based on the Position time.

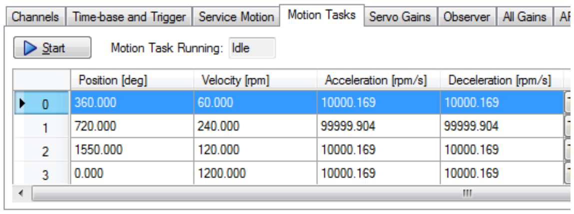
Service Motion

Service Motion allows a move or motion to be created from the scope screen. This can be very useful during the tuning or troubleshooting process. The motion can be a single pulse, Reversing motion, or a continuous move.



Motion Task

From the scope screen a motion task can be called. Using the motion task in the scope will allow the exact motion required for the application to be triggered and captured. A plot of the motion task can show any problems in the motion that may be occurring.



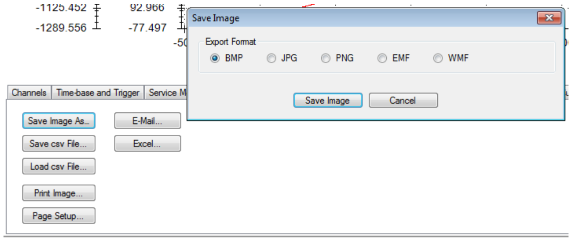
Servo Gains

Servo Gains, Observer, All Gains, and AR Filter will be addressed in another class. All of these can be seen from the scope screen and changed to improve the system performance. As always, care should be taken when changings gains and filters as systems can become unstable.

Save & Print

After a scope plot has been taken it may be important to share the scope plot with your colleagues commissioning purposes, troubleshooting or bragging right.

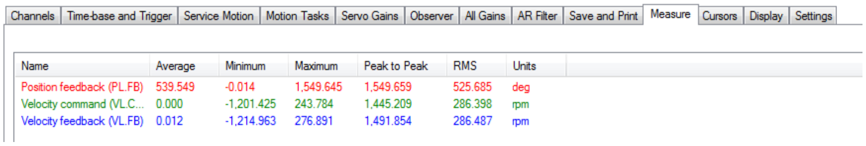
The scope plot can be saved as an image in BMP, JPG, PNG, EMF or WMF format.



The plot can also be saved in a csv (Comma Separated Values) file format which will allow the data points to be brought into an Excel Spread sheet. This can be very useful when evaluating the data collected.

The scope plot can also be sent to a print to create a hard copy. Associated with the print tab is the Page Setup tab which allows the page to be set to the most practical format for display. For example, Landscape or Portrait.

Measure



The measure tab allows basic information to be displayed. The data displayed is that set in the Channels tab and will indicated the Average, Minimum, Maximum, Peak to Peak, and RMS values. The data will be displayed in the units set for the system.

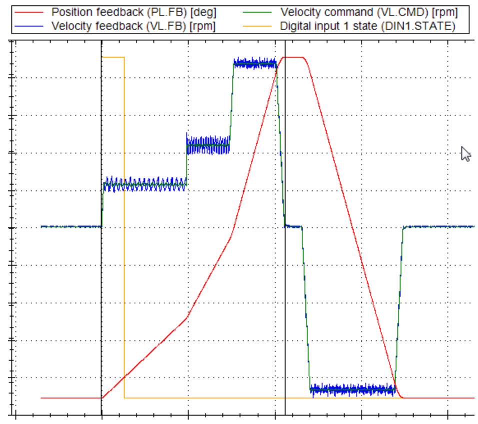
The average value is based on the sum of the data points divided by the number of data points. The minimum and maximum values are the highest and lowest data points. The Peak to Peak value is the value from the minimum to maximum values.

RMS (Root Mean Square) is the geometric average of the value.

Cursor

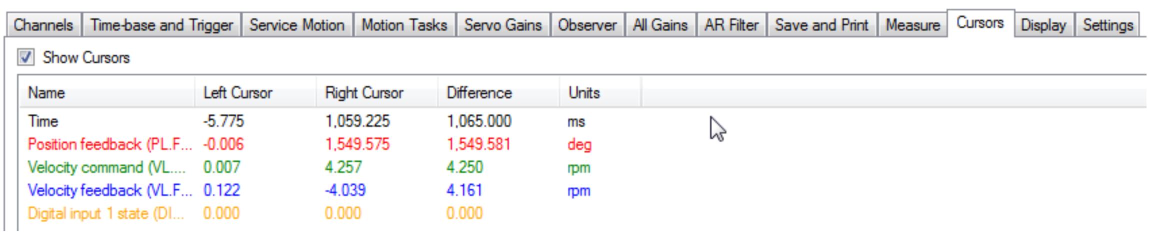
To measure the values between two points the cursor can be used. The left Right Cursors can be moved to their positions and the distance between them in Time and the set units can be displayed.

In the example the left cursor is set on the rising edge of the digital input 1 state. The right cursor is set at the end of the last motion task before the return move. Between the two cursors is the measured time, Position, Velocity Commanded and Velocity.



We can see from the measured data that the move time is 1,065.000 milliseconds, or approximately 1 second.

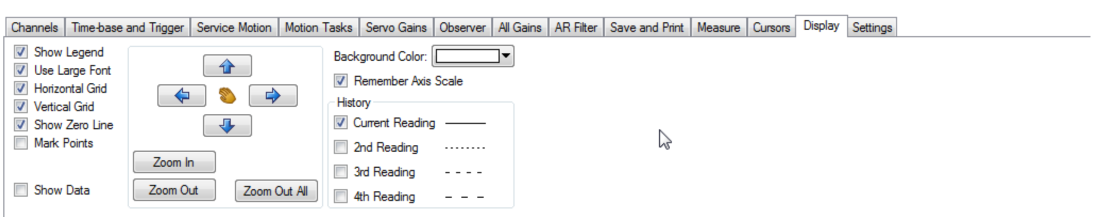
Since the motion task is set to move out 1,550 degrees and returning to zero, the position is measure just before the return move. If it was measured after the return move it would read approximately zero. We measure the distance moved as 1,549.581 degrees.



Name	Left Cursor	Right Cursor	Difference	Units
Time	-5.775	1,059.225	1,065.000	ms
Position feedback (PL.F...	-0.006	1,549.575	1,549.581	deg
Velocity command (VL....	0.007	4.257	4.250	rpm
Velocity feedback (VL.F...	0.122	-4.039	4.161	rpm
Digital input 1 state (DI...	0.000	0.000	0.000	

Display

The Display tab allows adjustments to the displayed data to make the interpretation of the data easier. Controls allow the viewer to zoom In and Out, Pan Left and Right, display the current data along with the last three.



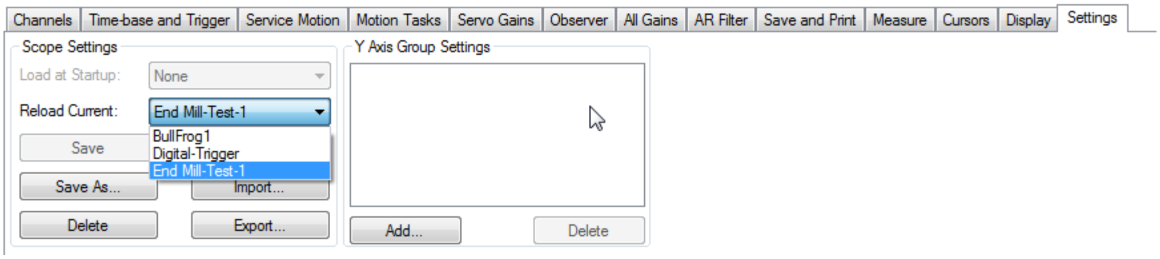
The legend can be removed, the Font enlarged, Horizontal and Vertical grids added or removed, and a Zero Line displayed. The data points can be marked as well, but with a large number of data points the display can be cluttered.

Show Data will display the individual data points and their magnitude.

Zoom Out All will return the display to its original state.

Settings

Settings allows for a series of Preset Scope settings to be created. These settings can be retrieved and used as needed.



Clicking on the Reload Current tab will bring down the list of preset scope settings. Loading a preset will set the Channels to be recorded, the recording time, triggers etc.

The preset scope settings can be exported to the computer's memory and shared as you would any other file. Files can also be Imported and used. This is very helpful during long distance troubleshooting where the data being collected will need to be as close as possible.

AKD™ Motion Task

Homing

Before a position move can be executed, the home position must be established. Workbench provides fifteen different methods to home a system and the type selected will depend on the application and mechanics to which the motor is connected. Each home mode provides flexibility when working with the application.

To select the proper home mode, HOME.MODE, will require an understanding of the application. If the application does not require a known starting point, such as the case for a conveyor that must index a set distance on a trigger, then a simple home type can be used. Home mode 0, “Home using current position”, can be used. This will basically allow the current position to be the starting point.

Mode	Description
0	Home using current position
1	Find limit input
2	Find limit input then find zero angle
3	Find limit then find index
4	Find home input, including hardware limit switches
5	Find home input then find zero angle, including hardware limit switches
6	Find home input then find index, including hardware limit switches
7	Find zero angle
8	Move until position error exceeded
9	Move until position error exceeded, then find zero angle
10	Move until position error exceeded, then find index
11	Find index signal, without any precondition
12	Homing to a home-switch, including mechanical stop detection
13	Home using the feedback position
14	Find home input – Only in given direction

Home Mode Types

The home mode types can be broken into: use current position, find the limit switch, find the home input, move until position error exceeded, and find zero angle or index. Each of these can be modified to provide an offset from the home position.

Home Type 0

Mode Type 0, use current position, will make the current position the home point. Although a very basic home type, it can be modified using Offset and Position. This means the current position doesn’t have to be defined as zero, but can be given any desired position, and the load can be moved from this position.

Mode Type 0 is very useful when you have a device that is not concerned with the actual starting point such as a conveyor that will index a defined distance once an input has been triggered. In other words, where it is beginning is not as important as where it is going.

Home Types 1, 2 & 3

Using Mode types 1, 2, and 3 we see that this is basically looking for the limit input, or End-Of-Travel switch (EOT). Modes 2 and 3 have the added "… then find zero angle" and "… then find index." Each feedback device will have either the zero-angle or the index. SFD, EnDat Sine Encoder, BiSS, and Resolver will have the zero-angle. The incremental encoder with and without Halls will have the index. These are precise positions in the feedback device that do not change unless the motor or feedback is changed.

Home Types 4, 5 & 6

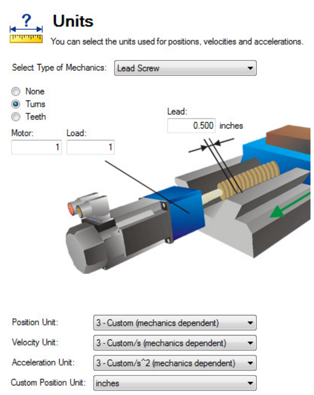
Using Mode Types 4, 5, and 6 will be looking for a dedicated input specifically for the Home Reference. This input can be a snap action switch, which is inherently inaccurate, or a non-contact type switch such as Hall Effect, Inductive Proximity, Capacitive Proximity, or Photo-detector Proximity switch. As with Mode Types 1, 2, and 3, finding the Home Reference input can increase the accuracy by adding the zero-angle or index.

Homing to a limit switch, home input switch, or a physical hard stop can provide a position that may fluctuate depending on the switch type, ambient temperature, or other environmental or material changes. For example if the machine is using home mode 8, which will drive the mechanical components into a hardstop, and the hardstop is a piece of rubber the position will change with temperature as the rubber softens or hardens.

To remove this inaccuracy due to temperature, the load can move to the hardstop then move off to the zero angle or index of the feedback device. This will make the homing very repeatable.

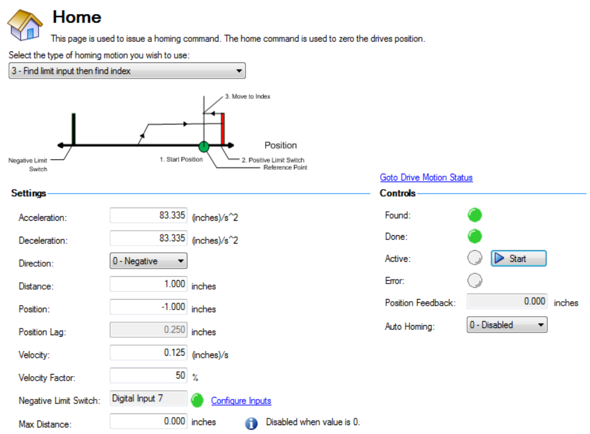
In most cases when homing to a limit switch or hardstop an offset is desired. The Home setup screen provides for this offset. The example below is for homing to a limit switch with an offset.

Homing Example:
Units have been setup for connection to a Lead Screw. The lead is 0.5"/rev. The Position Unit is 3-Custom (mechanics dependent) which will provide position in inches when Custom Position Unit is set to inches; Velocity Unit 3-Custom (mechanics dependent) which be in inches/second; Acceleration Unit is 3-Custom (mechanics dependent) which will be in inches/s².



For this example the load will be homed in the negative direction, a 1-inche offset will be provided, and the final position will be zero.

Velocity, Acceleration, and Deceleration have been set to moderate values. The Home Mode is set to type 3-Find limit input then find index (feedback is incremental encoder). The direction is set to 0-Negative; this will allow the moves to be positive from home. The position is set to -1, and distance is set to 1. This means when the limit switch is found the system will move off to the index position. This point is now defined as -1, then the system will move positive 1 inch. The Position Feedback now reads 0.00 inches.



⚠ CAUTION When homing to a limit switch the switch must be made long enough for the system to decelerate to zero and the switch still triggered. The switch can be overshot if the deceleration rate is very low and velocity is very high. A homing error will occur.

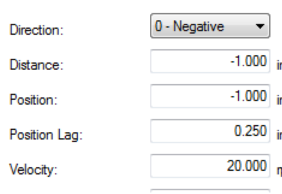
Home Types 7 & 11

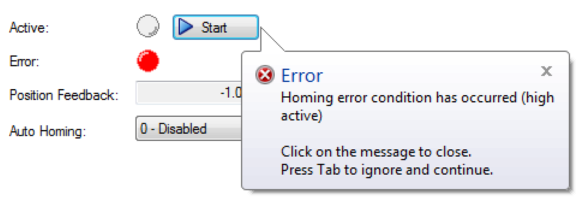
Home Types 7 and 11 are very similar. Both use the feedback device's internal reference point for homing. Homing using the zero angle or index and adding an offset can be used with each of the other Home Modes.

Home Types 8, 9 & 10

Home Types 8, 9, and 10, Move until position error exceeded, are commonly called Homing to a Hard-stop. Basically the current will be reduced to prevent damage and the load will be moved in one direction or another until the position error increases above the set value. Care needs to be taken to prevent damage of the mechanical system. The Peak Current limit set in the Homing screen needs to be high enough to overcome all frictions in the system, yet low enough to not damage the components.

A common mistake when using Home Modes 8, 9, & 10 is to have an offset move in the same direction as the home direction. For example using Direction: 0-Negative and Distance: -1. Since the system was moving in the negative direction when it encountered the hardstop, it cannot move -1 as this will be beyond the hardstop. The system will generate an Error as seen below.





Home Type 12

Home Type 12, Find home input (account for mechanical end stops) will allow a system to travel to a hard-stop, turn around, and continue looking for the Home Reference input. This home type removes the need for adding End Of Travel limit switches to the system. It is important to be aware that this system works similar to the Home Types 8, 9 and 10, except the hard-stop is the EOT. Peak Current will need to be reduced enough to prevent damage, but high enough to overcome frictions in the system.

Motion Task

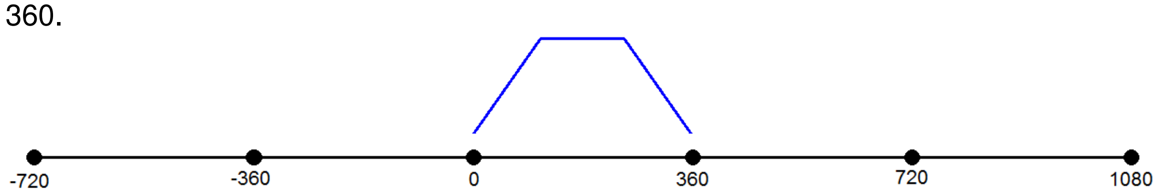
In many applications point to point moves are all that is needed. AKD and Workbench can allow simple to complex profiles to be entered into the drive and moves triggered by the I/O.

There are two basic types of move available in the motion task. These are Absolute and Relative moves. While both are motion types, when and how they are used is application dependent.

Absolute Move

Absolute moves are excellent when working in a finite space such as an actuator. Since the travel is limited to the length of travel in the actuator, Absolute moves help prevent an accidental move beyond the travel limits.

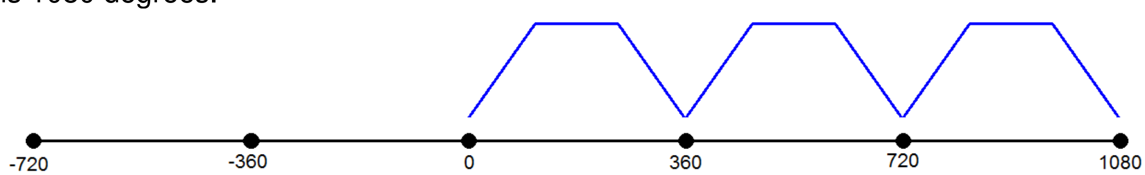
If the systems begins at 0 degrees and an absolute move is commanded for 360 degrees, the system will move to that point. There is only one point that is 360 degrees. If the move is repeated two more times the system will not move since it is already at 360.



Relative Move

Relative move, or Incremental move, is based on making a move of a certain distance. The starting point is irrelevant, since the move is starting from whatever point it is located at the time the move is initiated.

If the system begins at 0 degrees and a command to make a relative move is given the system will move to 360 degrees. If the command is given two more times the system will make two more moves each equaling a distance of 360 degrees. The final position is 1080 degrees.

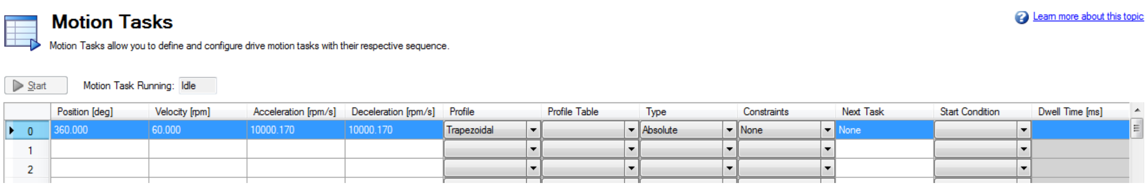


Relative moves are used in applications were the system can make repeated moves without coming to the end of travel such as indexing tables or conveyor systems.

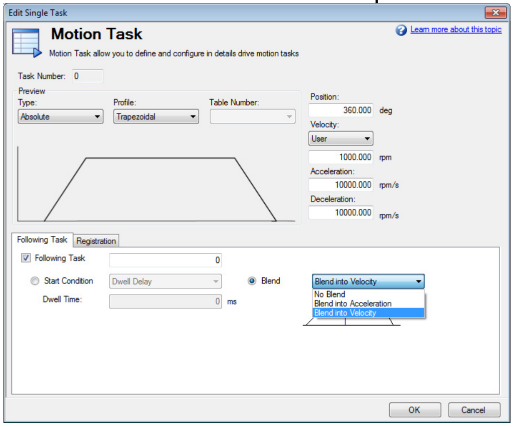
A clear understanding of Absolute and Relatives is required to insure that the correct move type is used in the application. As we can see from the two examples, if connected to an actuator with a travel limit of 360 degrees, the Relative move would have found the end of travel and possibly damaged the actuator.

Motion Task

There are two ways create a motion task. The first is to enter the data into the data spreadsheet. Below we see that a move of 360-degrees at 1000-rpm has been created. The spreadsheet can be expanded to the right to add the column for the Following Task, which is the task that will be executed after the current task, the Start Condition and Dwell Time if the Start Condition calls for a Dwell between the Motion Task.



The second method is to double-click the Motion Task number which will bring up the Motion Task screen. The Motion Task screen is for a single task. It provides a visual representation of the move and allows all the parameters to be edited in one place.



The type of move can be selected as:

- Absolute
- Relative to command position (PL.CMD)
- Relative to previous target position
- Relative to feedback position

The units for Position, Velocity, Acceleration, and Deceleration are defined in the Units Screen. It is important to set the Units appropriately for the application.

Following Task is the task to be completed after this Motion Task. They do not need go in order and jump around as needed.

One move can blend into the next as defined in drop down section. One task can blend into the acceleration or velocity of the next task. Scope plots of each Blend type can be found in **Appendix A**.

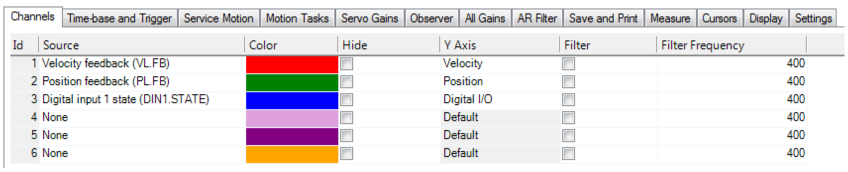
Exercise

Objective: to create a series of motion task connected together using different start conditions and blending that will be trigger from an I/O condition and captured using the Scope tool.

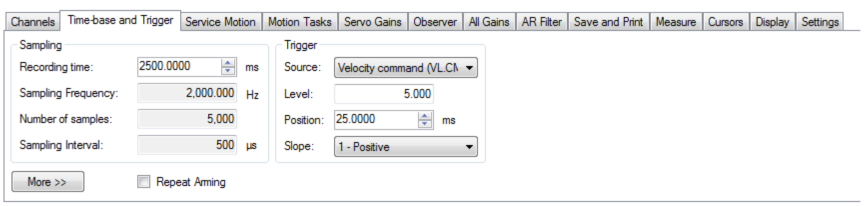
Setup the following motion task all of which will Absolute moves, Trapezoidal Profiles, and Acceleration /Deceleration 10,000 rpm/s:

Task No.	Position (degrees)	Velocity (rpm)	Next Task	Start Condition	Dwell Time
0	1200	300	1	Dwell Time	250
1	2400	600	2	Dwell Time	250
2	3600	1200	3	Dwell Time	250
3	0	2000	none		

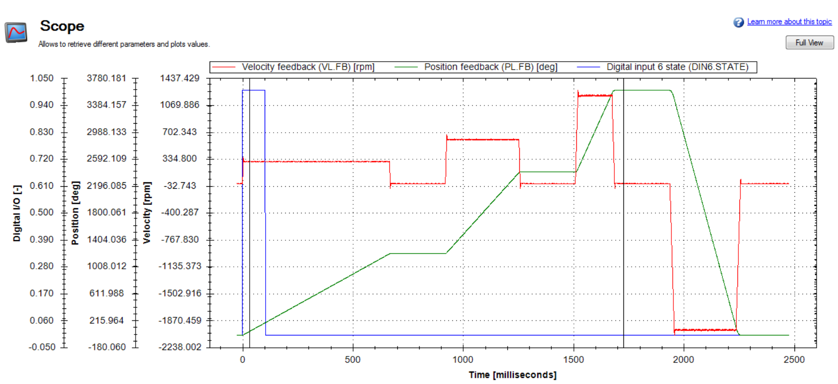
Set the scope to record VL.FB, PL.FB, and DINx.STATE for the digital input selected to start the motion task. In example, digital input 1 will be DIN1.STATE.



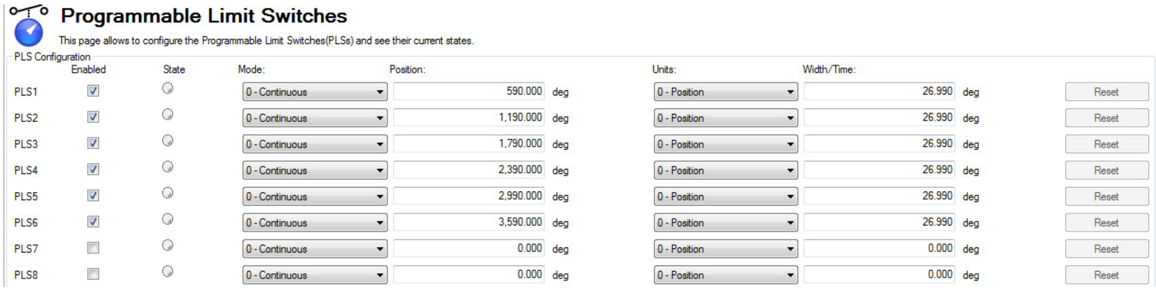
Set the scope to record 2.5 seconds of data, while triggering off the velocity command going greater than 5 rpm. Remember to set the slope to 1 – Positive to catch the rising edge. Arm the scope then trigger the motion task.



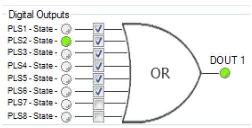
The example below is similar to what you should have displayed. The shape of the move profiles may vary due to tuning and load. The blue line is the digital input that triggered the move. The red line is the velocity profile for the moves. The green line is position during the moves.



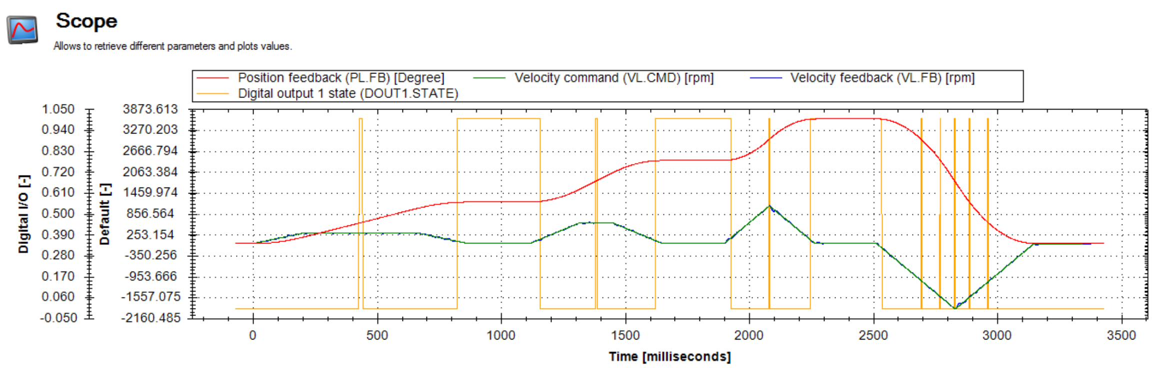
PLS – Programmable Limit Switches



To connect the states to the OR gate, the box must be checked. The state indicator will illuminate when that point is true, and will not be illuminated when not true.



PLS.EN enables the programmable limit switch. The range is 0 to 255, and is a binary representation of the 8 programmable points. PLS.EN 255 will be for all points on, while PLS.EN 0 is for all points off. Any combination of points can be enabled based on the binary value of PLS.EN. PLS1 is the least significant bit, and PLS8 is the most significant bit.

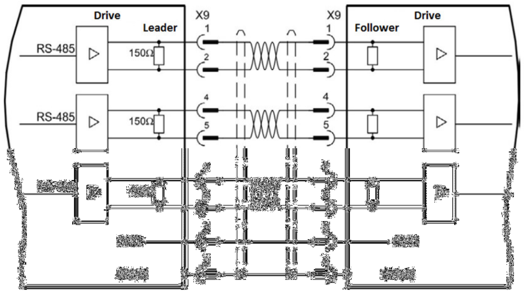


The above scope plot shows Digital Output 1 firing at the six set points.

Electronic Gearing

Electronic gearing allows two axis to be connected together digitally. Usually there is at least two axis involved, but it is not uncommon to have several follower axis. One axis is the Master, or Leader. The other axis, or multiple axis if more than one, is the Follower.

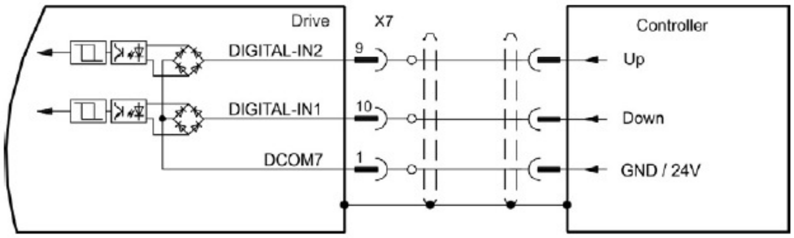
The AKD can be setup as either the Leader or the Follower, but not both. Each axis will be setup individually. When using AKD connector X9, the connection will be one to one.



One to one connection means pin-1 on one connector is connected to pin-1 on the other connector. Pin-2 is connected to pin-2, and so on and so forth.

It is important to observe all grounding, shielding and bonding procedures to insure good performance of the system.

AKD connector X7 can also be used for electronic gearing. It can be used for 24 volt signals to provide an up-down control. This commonly used when a third-party controller is being used to deliver the signal.

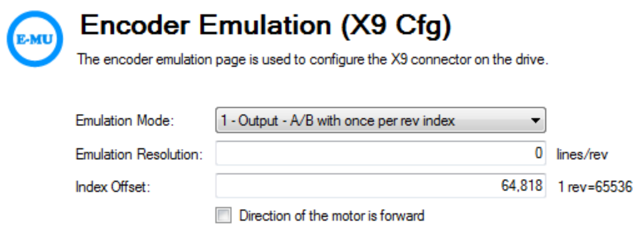


It is important to note that this configuration is single ended and provides very little noise rejection. It is very important to shield and ground the signal carrying cable.

Leader

The leader is the easier of the axis to setup. This will basically consist of setting up the Emulated Encoder Output (EEO). The EEO is set in the Encoder Emulation screen.

Emulation Mode is the type of output the AKD will generate. The more common is mode 1-Output A/B with once per rev index. This simulates an A quad B encoder. The Emulation Resolution is here in lines/rev.



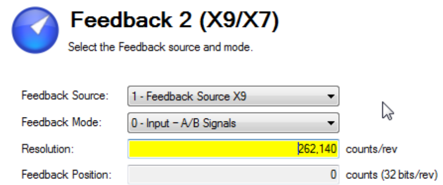
The leader Emulation Resolution is from 0 to 16,777,125 lines/rev. Lines/rev is before quadrature. Post is found by taking the resolution time four (lines/rev x 4 = counts/rev).

Follower

The Follower has a more complex setup compared to the Leader. Because the Follower will be receiving the input, Encoder Emulation is set to 0-Input (No EEO Output).

The Follower Axis will be setup for the example below. The connection will be from X9 to X9 through a 9-pin Sub-D female-to-female cable. The cable is shielded and the shield is tied to ground.

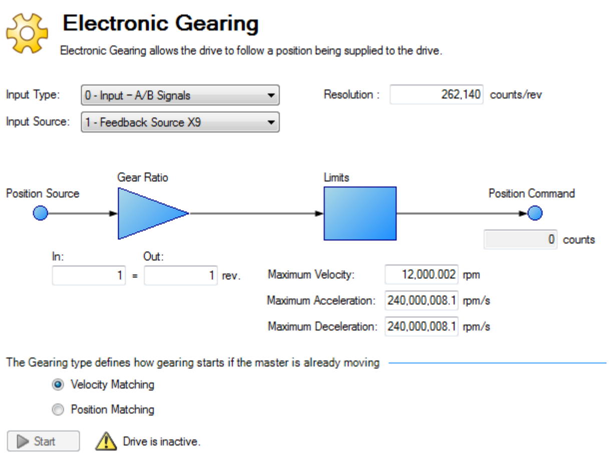
Feedback 2 will be setup for X9.
Feedback mode is 0-Input A/B Signals.
Resolution is set to 262,140 counts/rev.



The Follower must be setup for DRV.CMDSOURCE 2-Electronic Gearing. When the command source is set Electronic Gearing an additional branch will appear on the tree.

The Input Type and Input Source will reflect that which was set in the Feedback 2 screen.

The ratio between the Leader and the Follower can be set here in the In = Out tabs. A 2:1 ratio can be set as In: 2, Out: 1, or In: 200, Out: 100, or any combination that will be equal 2:1. This flexibility becomes helpful when ratios such as 15.5:1 are required. The values for In and Out must be integers, so this will be set as In: 155, Out: 10.



While In (GEAR.IN) has a range of 1 to 65,535, Out (GEAR.OUT) has a range from -32,768 to 32,767. Since Out can be negative it can be used to counter rotate two axis, or correct for axis in which one motor is mounted opposite another.

Limit can be set for the Follower axis using the Maximum Velocity, Maximum Acceleration, and Maximum Deceleration. In most cases it is best to set Acceleration and Deceleration as high as possible. Limiting Acc and Dec and adversely affect the system performance.

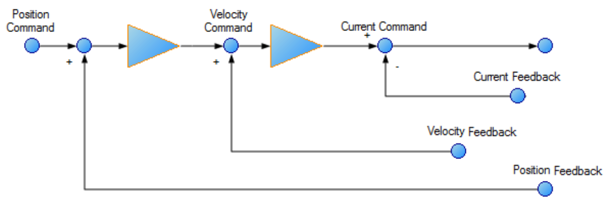
The Gearing Type defines how gearing will start if the Leader is already in motion. Since the electronic gearing can be used to synchronize two axis, it should understood relationship between the Leader and Follower.

If the follower is only meant to come up to the same speed as the Leader then Velocity Matching will be used. Position Matching is used when the Leader and Follower need to be lock together by their position. When engaged, the Follower will speed up and recover the steps lost during the acceleration.

Tuning

Introduction

In a perfect world tuning a system would not be required. In the “Real World” tuning a system is a necessity.



A servo system is a closed loop system which will continually monitor and adjust torque, velocity, and position to achieve the desired trajectory. A servo system can operate in torque mode, or velocity mode, or position mode. In the diagram above can be seen a simplified diagram of these three loops.

The tuning begins at the right with the current loop which is tuned for the motor. The current loops function is to insure that as much current as possible can get into and out of the motor as quickly as possible. The current loop does take into account the load and doesn’t even care if a load is connected or not.

The velocity loop is added to the current loop. The velocity loop is tuned after the current loop and is tuned specifically for the load. The tuning is basically telling the drive how it needs to react to any change in velocity. If the load is very small, J_L/J_M=1:1 or less, a slight change in velocity does not warrant a huge injection of error into the system to correct for this change.

At the other end of the spectrum is a large load, J_L/J_M =1,000:1. Since the load will create a large opposition to motor, a larger error will need to be injected into the system to insure enough torque is generated to overcome the load and correct the change in velocity.

The position loop can be added to the velocity loop and current loop after they have been tuned. The position loop is now monitoring the position as well as velocity and will need to be tuned for the load for the same reasons the velocity loop is tuned for the load.

The AKD provides several paths for tuning the system from the Slider Tuner to the Performance Servo Tuner which can tune in Automatic Mode or Manual Mode. Accept for the most extreme cases, the AKD can be tuned to provide excellent performance with high inertial loads, systems resonance, and poor mechanical components.

The Key to good servo performance is to begin with a sound mechanical system!

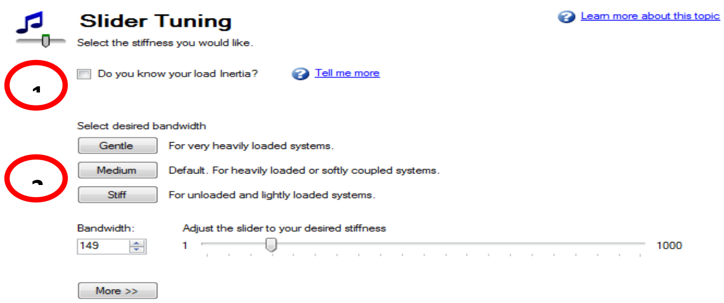
Slider Tuning

The slider tuner is a simple easy to use tool that can get most servo systems up and running in just a few minutes. It requires two pieces of information:

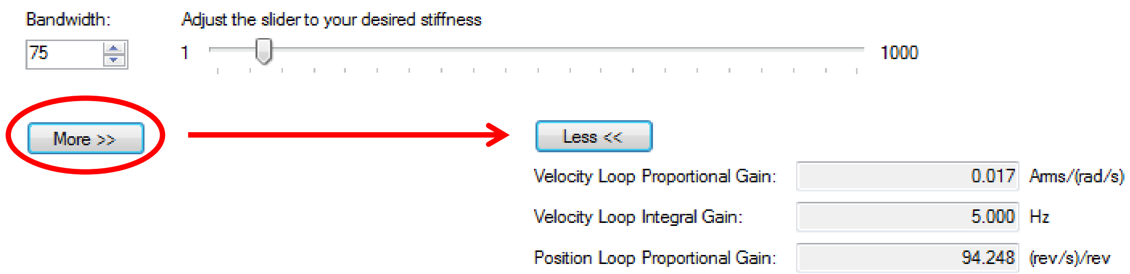
Load inertia
Desired bandwidth

Bandwidth

The desired bandwidth can be entered by using the gentle/medium/stiff settings which represents 25Hz, 75Hz, or 200Hz respectively. You can also type in the desired bandwidth, or use the slider bar itself to increase the value.



The "More>>" button opens the screen to identify what specific gains are being set, and to what values.



Important Notes: The slider tuner does modify one of the digital filters (Biquads) and tunes a low pass filter based on the bandwidth selected. It is important to keep track of any filters that are present to maintain stability. The Slider tuner does not configure any feed-forwards (current, friction, velocity, acceleration, etc.). Manual set up may be required to optimize motion profiles.

What Bandwidth is required?

The simple answer is based on just how fast you need the system to settle from disturbances or motion. Knowing your desired settling time allows you to calculate your system bandwidth:

System Bandwidth = 1/Settling Time (seconds)

Slider Tuner – How it Works

How does the slider tuner know what the tuning gains should be just from the bandwidth and load inertia? Slider tuner will set four parameters, VL.KP (velocity proportional gain), VL.KI (velocity integral gain), PL.KP (position proportional gain), IL.KP (current proportional gain), and one biquad filter, AR1. Let's look at each one individually:

First – VL.KP, or Velocity Proportional Gain

$$VL.KP = 2\pi * BW * JM * (1+JL) * 0.0001 * Kt$$

J_M and J_L are in units of kg-cm^2, BW in in Hz, and K_t is N-m/A_{rms}

VL.KP will bring the gain of the system up to a specific performance rating (bandwidth). Therefor it is based on how strong the motor is (K_t – the motor torque constant) and how much mass is attached to the motor (J_M – motor shaft mass and J_L – load mass).

Next we look at VL.KI, or Velocity Integral Gain

VL.KI = BW * tan(2.5°)

BW and VL.KI are in units of Hz

There is no standard to how much velocity integral gain is needed on a system. The slider tuner makes a conservative assumption and sets the Velocity Integral gain to contribute only 2.5 degrees of phase loss at the bandwidth requested.

Next, we look at PL.KP, or the Position Proportional Gain

PL.KP = BW * tan(2.5°) * 2π

BW is in units of Hz, PL.KP is in (rev/s)/rev (can be converted to Hz by dividing by 2π)

The required Position Proportional gain will also vary from system to system. The slider tuner sets the Position Proportional gain to contribute only 2.5 degrees of phase loss at the bandwidth requested.

Our next parameter is IL.KP, or the Current Proportional Gain.

IL.KP = IL BW * tan(2.5°) *2π * Motor Inductance (mH)

Where BW is in units of Hz

First a current loop bandwidth must be calculated:

IL BW = 75 Hz / tan 5 = 857 Hz

Next, IL BW (Current Loop Bandwidth) is clamped between 1000 Hz and 2000 Hz to maintain numerical accuracy and stability.

IL BW = 1000 Hz

Note: Default tuning will leave the current loop with ~1000 Hz bandwidth. If manual tuning is used to achieve more than a few hundred Hertz, IL.KP will need to be manually increased appropriately.

Finally, AR1 is set as a low pass with a cutoff frequency calculated to cause no more than 8.5 degrees phase loss at the requested frequency.

$$filterFreqhz = (-(\cos p2*bw4-4*bw2*50002+50004-2*\sin p*\cos p*bw*bw2-50002*5000*2+2*(bw4-bw2*50002+50004)-\cos p*bw2-50002-\sin p*bw*5000*2)*bw2*\cos p*bw*5000-\sin p*bw2-50002*2$$

Yes – this is a BIG equation and very cumbersome than most would like. However, since the slider tuner is limited over a small frequency range (no larger than 300 Hz bandwidth), an acceptable substitute is:

AR1 Frequency = 9 * BW

Important Note: All systems are different. Integral gains can be sensitive to mechanical oscillations and friction. The slider tuner may not be appropriate for some applications.

Limitations of Slider Tuner

Why use anything else? The slider tuner is very simple to use as it can get simple mechanical assemblies tuned reasonably well with little fine tuning. When mechanical systems get beyond a simple rigid load, more tuning finesse is often required to handle the complex resonances created by complicated mechanics.

Common systems that may not be able to be optimized using the slider tuner:

Belt driven loads	High friction mechanics
Multi-staged loads (multiple resonant loads)	Low resolution feedback
Linear motors	Unknown inertia loads

Unfortunately, the slider Tuner won't work for every system. This is primarily because the slider tuner does not measure any part of your motor or mechanics and assumes the ideal case. It also assumes the load inertia you entered includes all of your loads. Rarely are mechanical systems ideal – there is always something unexpected like friction, imprecise manufacturing of components, belt tensioning, and even variations from machine to machine.

In these cases, solving advanced problems will require just a bit more work. Using the AKD Performance Tuner feature, it is possible to measure your physical system and tune on what is actually, physically there, even if there are variations from machine to machine. The Performance Tuner allows you to visualize these problems and adjust tuning accordingly.

Projects

Project #1 Bode Tool & Tuning

On your hard drive create a folder called: AKD Projects.

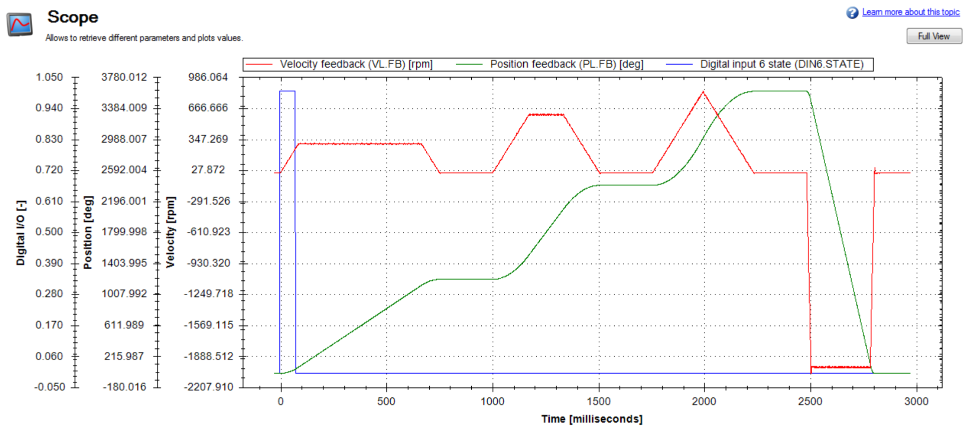
1. Take a Bode Plot of your system and save it to your project folder.
2. Set the tuning using the Slider Tuning.

Appendix A – Always Under Construction

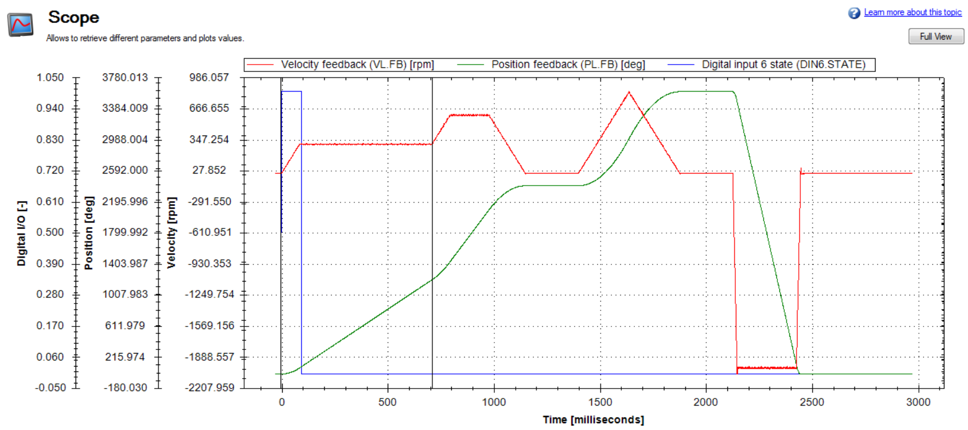
Blending Moves

When a more complex move is require, moves can be connected together using the Blend feature. The move can be connected without any blending, or blended into the acceleration or velocity of the next move. It should be noted this will only work for those motion task of the same direction.

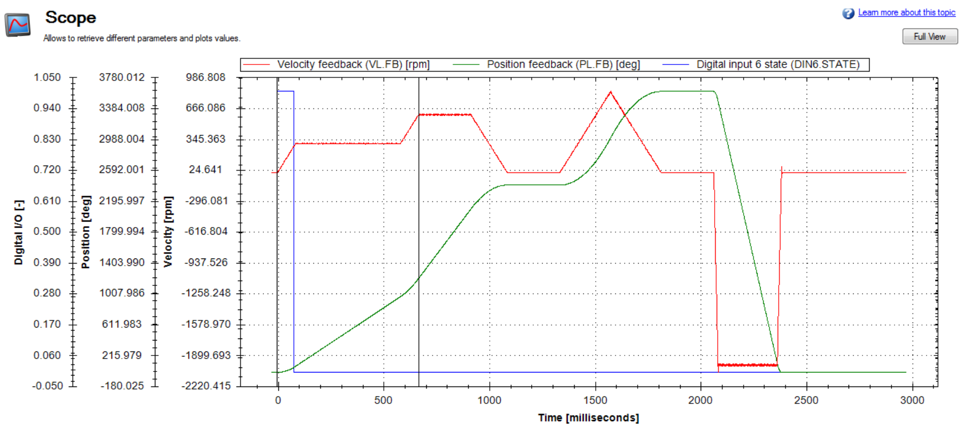
250 millisecond dwell between moves. The distance, acceleration, and decelerations are the same for the motion task, but the velocity is different. The results are three moves with the acceleration and distance covered, but different times to complete the move.



Motion Task 0 blended into the acceleration of Motion Task 1.



Motion Task 0 blended into the velocity of Motion Task 1.



Appendix B – Under Construction

Under Construction

About Kollmorgen

Kollmorgen is a leading provider of motion systems and components for machine builders. Through world-class knowledge in motion, industry-leading quality and deep expertise in linking and integrating standard and custom products, Kollmorgen delivers breakthrough solutions that are unmatched in performance, reliability and ease-of-use, giving machine builders an irrefutable marketplace advantage.

For assistance with your application needs, contact us at: 540-633-3545, contactus@kollmorgen.com or visit www.kollmorgen.com

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