ADVANCED MOTION CONTROLS

DriveWare 300 Startup Guide

Rev 3.0.3a

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# Foreword

This startup guide will provide an overview of connection and basic setup instructions for Advanced Motion Controls 300 series drives using the DriveWare 300 software. The basic setup of a digital drive is designed to be analogous to the setup and tuning of an analog amplifier. These instructions will walk you through the following steps necessary to start up your drive and motor. All information within this document can be found in the help files included with DriveWare 300. This document is intended for setting up the drive. The help files contain more detailed information not included in this document. The following major sections are covered:

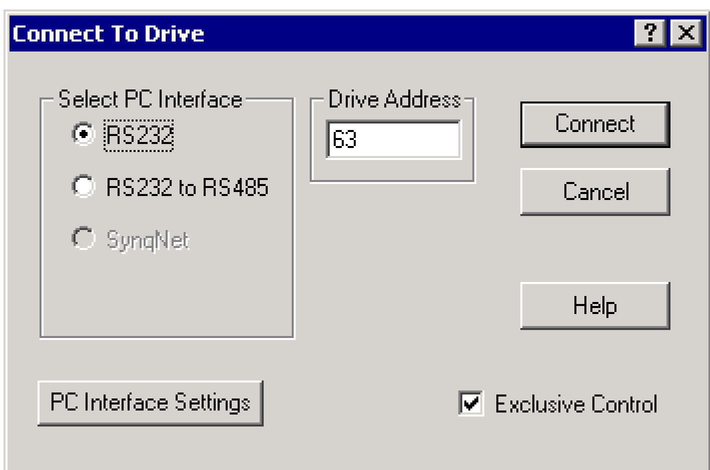
1. Connecting to the Drive
2. Drive Parameter Configuration
3. Tuning and Commutation
4. Command Input and Scaling

# Connecting to the Drive

You may open the 'Connect To Drive' window by selecting **Connect To Drive** when DriveWare is started. You can also open it by selecting **Communication** > **Connect** on the menu bar, or by clicking on the toolbar. You must initially connect to the drive using the factory default settings stored in nonvolatile memory and the appropriate serial port selected from the PC. Once communication is established, you may change the address and baud rate settings by going back into the **Connect To Drive** window**,** choosing your desired settings, and hitting **Connect**. The new settings will take effect immediately. In order to retain the new settings upon power-up, they must be stored in nonvolatile memory (see Communication, Store).

The following window appears when **Connect** is selected from the toolbar or file menu or when **Connect to drive** is selected from the opening page.

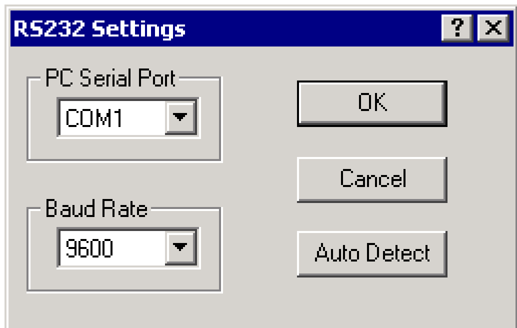
**Connect To Drive Window**




- **PC Interface Settings:** Selects the type of communication used between the drive and PC.
- **Drive Address**: Selects the address of the drive that is connected to the PC. The factory default setting is 63, where the valid range of addresses is 1 - 63.
- **PC Interface Settings:** When selected, a new screen pops up and allows you to select the appropriate serial port and baud rate (see PC Interface Settings Window below).
- **Connect:** Establishes a connection with the specified settings. When connecting, you can choose to download the current project settings to the drive, or to upload the stored drive settings into the project. The status bar in the lower right corner of DriveWare will change from NOT CONNECTED to CONNECTED.

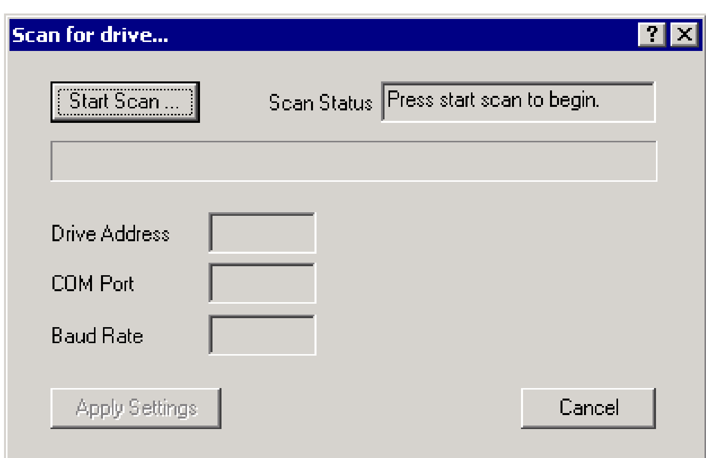
- **Cancel:** Closes the connection window without connecting.
- **Help:** Brings up the help document.
- **Exclusive Control:** This checkbox should always be checked when configuring your drive through DriveWare. For CANopen drives (ZDCR and DCR drives), you may uncheck the box to put DriveWare in a read-only state that allows monitoring through DriveWare while writing to through the CANopen interface.

**PC Interface Settings Window**




- **PC Serial Port:** Selects the serial communication port to which the drive is connected. The factory default setting is COM1
- **Baud Rate:** Selects the communication baud rate. The factory default setting is 9600.
- **Auto Detect:** This button allows you to automatically detect the serial port and baud rate stored in your drive. When this button is selected, the screen shown below will pop up. Select **Start Scan ...** and wait for the program to go through the detection routine. After successful detection, select Apply Settings. Note: a drive must be properly connected to a serial communication port of the PC for proper detection.

**Auto Detect Window**



# Drive Parameter Configuration

This is the first step in configuring the drive. In order to tune and commutate a motor, the drive must have information about scale factors, feedback devices, motor parameters, and limits. In DriveWare, each of the windows in the table below must be filled out with accurate data.

The easiest way to configure a new drive, or one that has had a factory default project file downloaded to it is to use the **Drive Configuration Wizard** . The wizard walks you through each of the necessary windows to configure the drive parameters. Once the wizard is complete, the drive will be ready for Command Input and Scaling. To use the wizard, select Tools > Wizard on the main menu bar, or click on the drive configuration wizard icon , otherwise find each of the following tables in the DriveWare software and fill in the appropriate information.

It is not required to use the wizard to configure your drive. The table below shows where to find each window in the setup software.

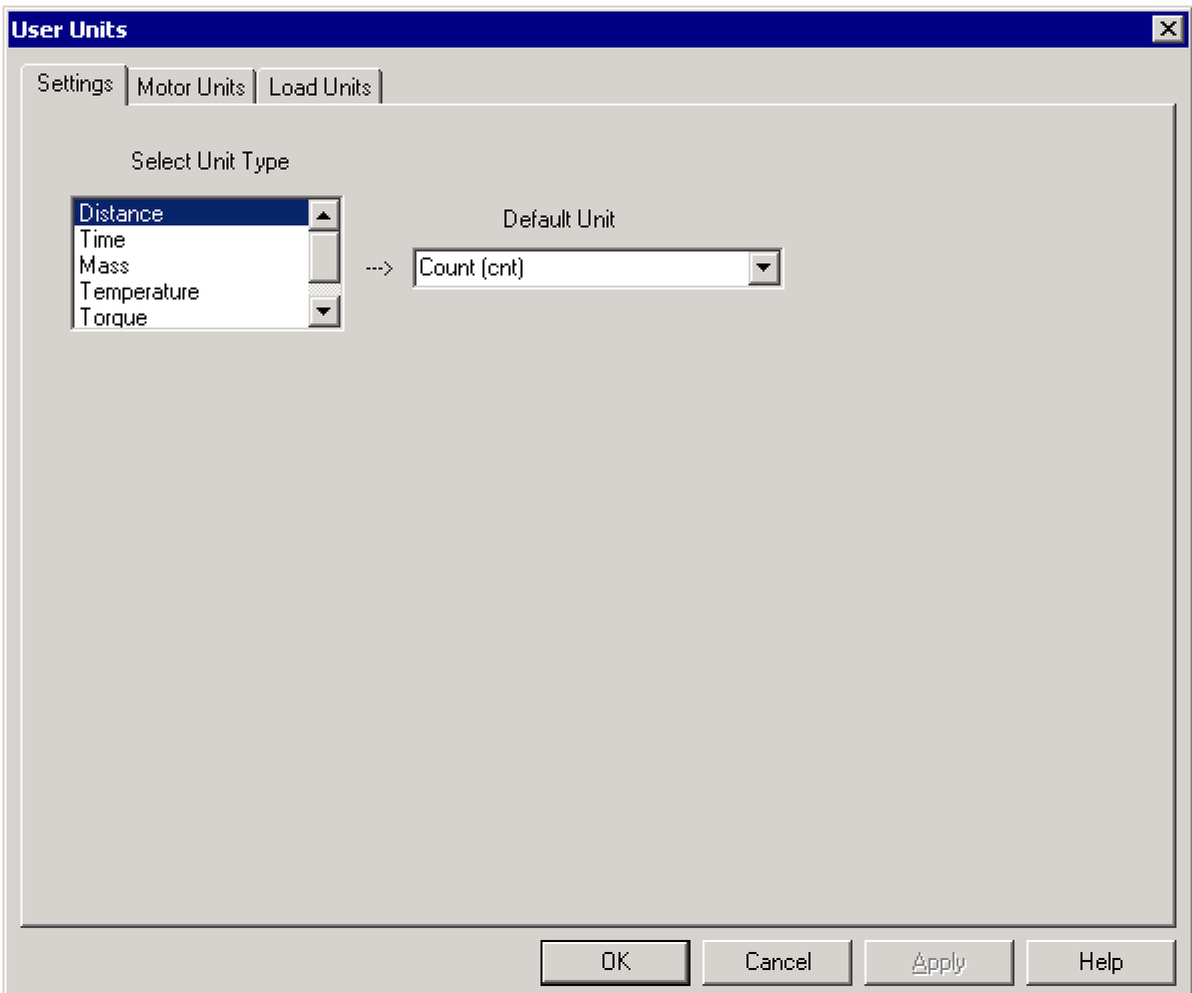
| DriveWare Window | Navigation when not using Wizard |
|---|---|
| User Units | Options > User Units |
| Motor Data and Primary Feedback | Main Block diagram > Motor Data block > Motor Constants tab |
| Load Data /Feedback | Main Block diagram > Load Data block |
| Feedback | Main Block diagram > Motor Data block > Primary Feedback tab |
| Drive Configuration | Main Block diagram > General Drive Configuration |

It is left to the user to click through the tabs and fill in the appropriate data once the wizard navigates to a window.

### *User Units*

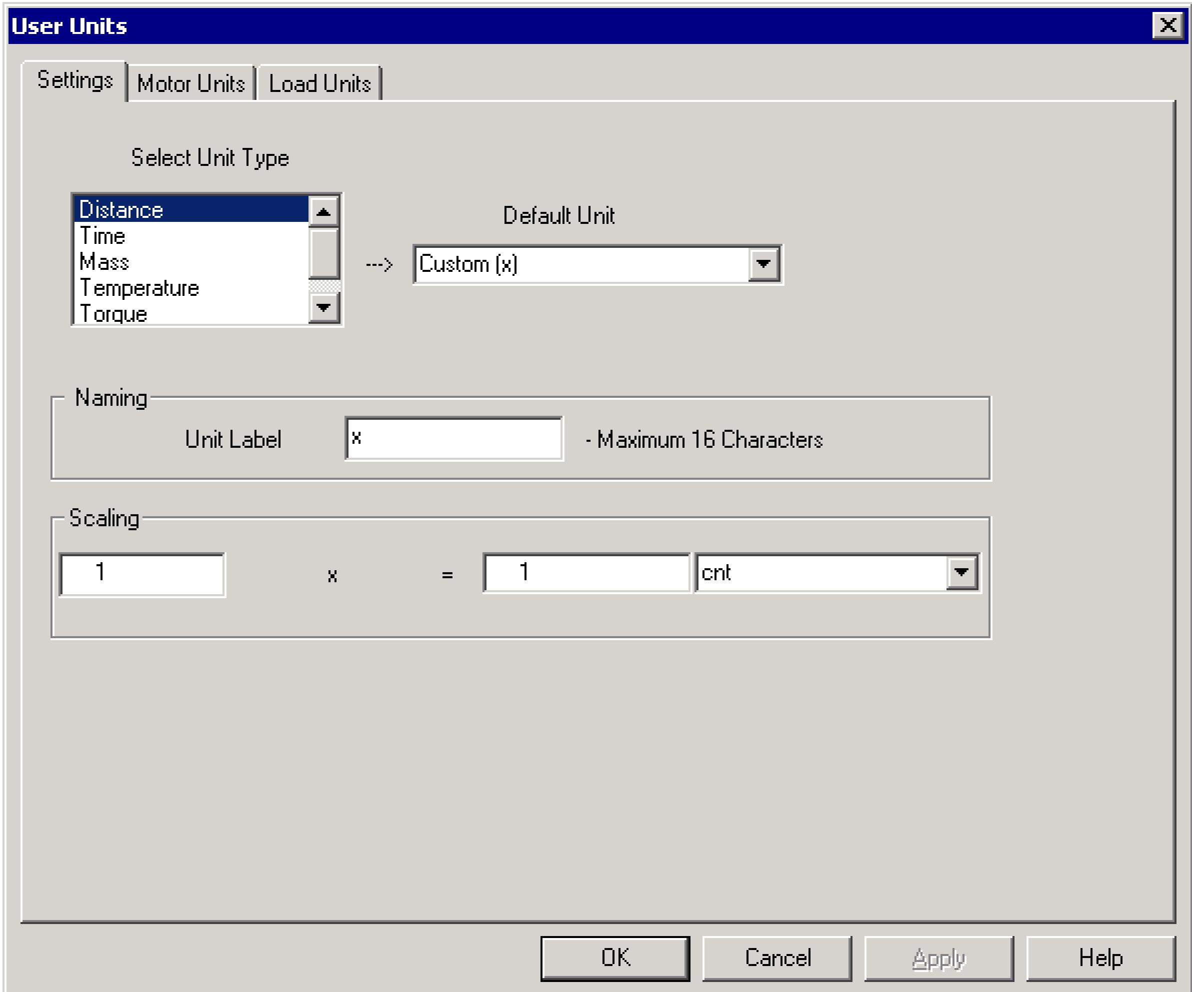
The User Units window allows you to select which units you would like to use for your motor and load. This makes it easier, for example, to track your motor speed in RPM while you track your load speed in m/s. A variety of units are selectable, and even custom units may be defined and used. The User Units window is selected by going to Options > User Units on the main file menu.

**Settings Tab**

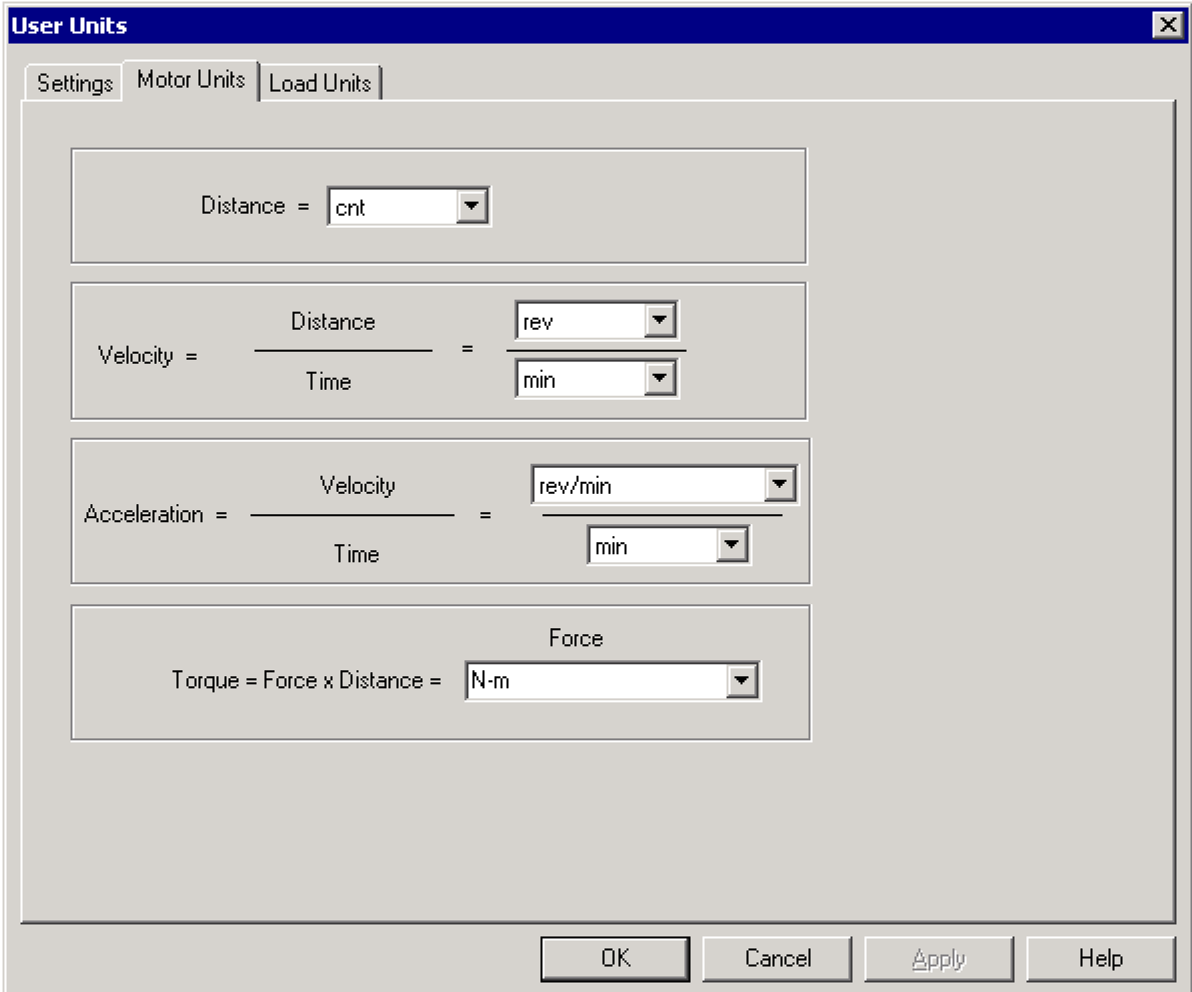



The settings tab allows you to set the general units you will use in DriveWare300. Select the type of unit (Distance, Time, etc) from the Unit Type drop down menu. Select the corresponding units from the Default Unit dropdown menu.

You may also define custom units by selecting 'Custom (x)' under the Default Unit dropdown menu. Once selected, you may choose any name you like to define your custom units.

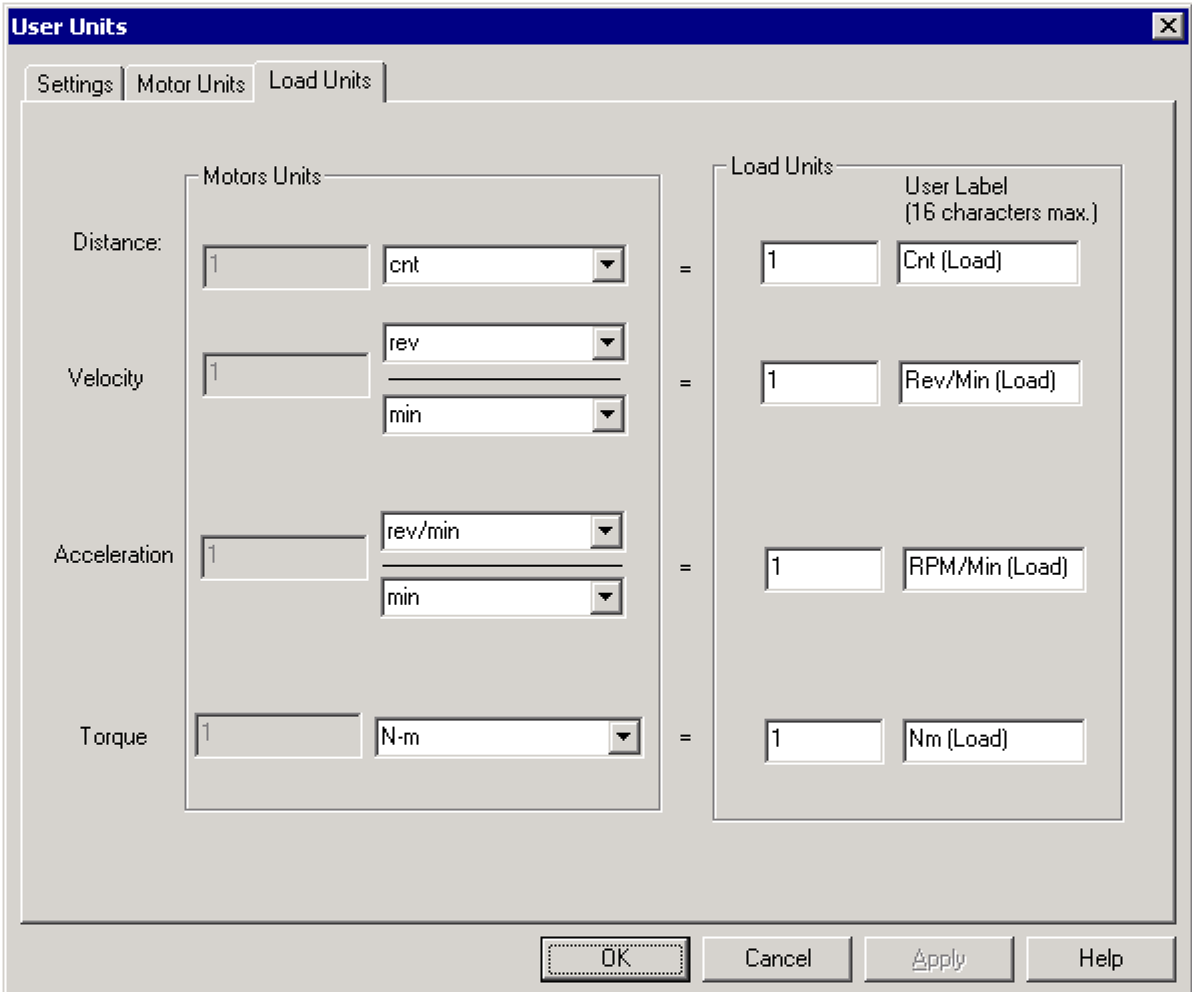

User Units
Settings
Motor Units
Load Units
Select Unit Type
Distance
Time
Mass
Temperature
Torque
Default Unit
--->
Custom (x)
Naming
Unit Label
x
- Maximum 16 Characters
Scaling
1
x
=
1
cnt
OK
Cancel
Apply
Help

**Default Motor Units Tab**




The motor tab allows you to select the units that correspond to your motor. The dropdown menu includes common units as well as any custom unit you may have defined in the settings tab.

### Load Units Tab




The load units tab allows you to define which units will describe your load. If you are using a gearbox, you may select the gearbox checkbox to automatically assign gear ratios to the units.

### *Motor Data and Primary Feedback*

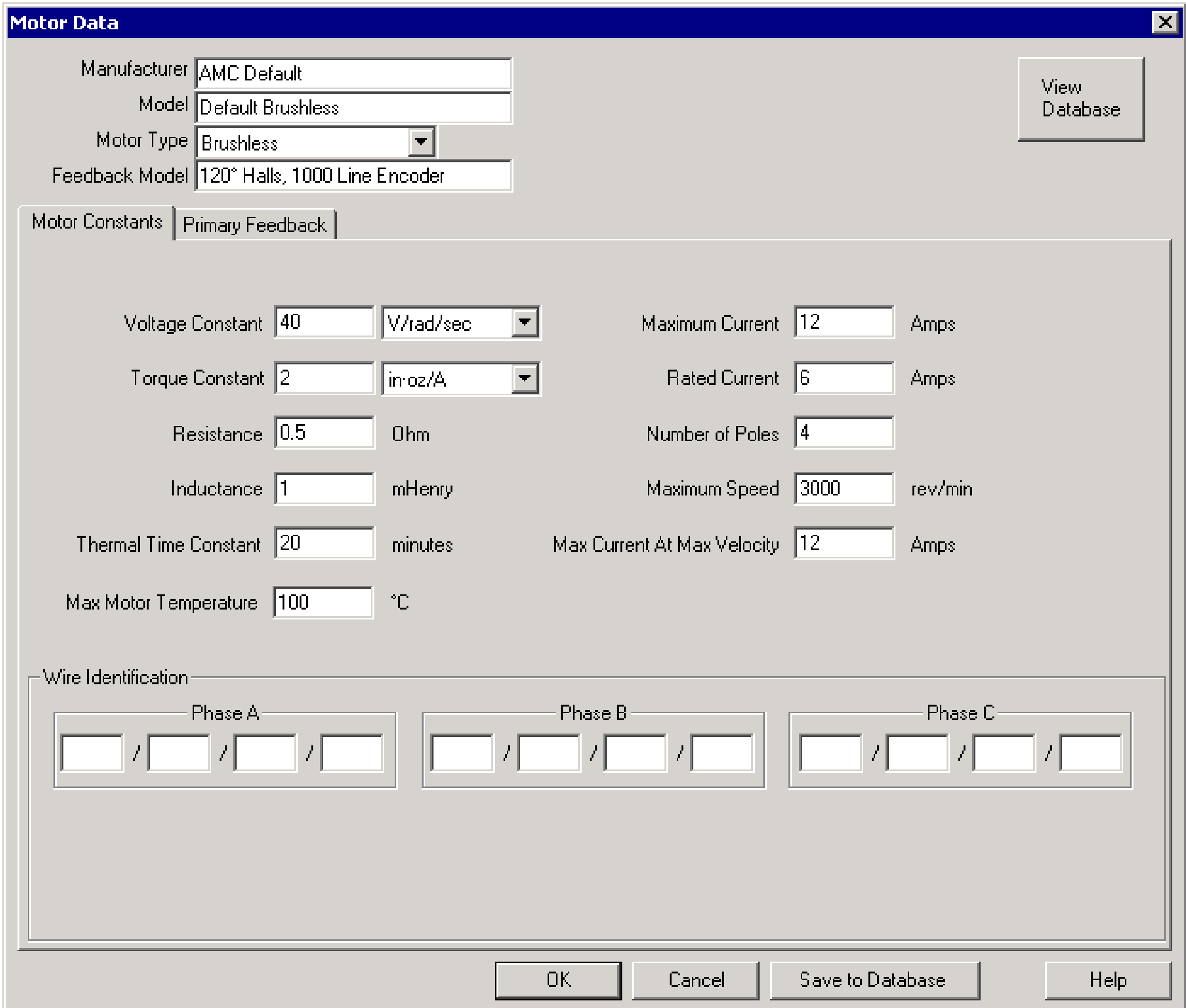
The motor data and primary feedback windows can be accessed by clicking on their corresponding icons in the main block diagram.

**Motor Data**

- The motor data will be stored in the drive and the project file and can also be stored in the motor database.

| | |
|---|---|
| Manufacturer | The name of the motor manufacturer. |
| Model | The motor model |
| Motor Type | The type of motor used. The brush and brushless motor types pertain to rotary motors. The linear brushless motor type pertains to linear motors. |
| Feedback Model | The name of the type of feedback to be used with the motor |

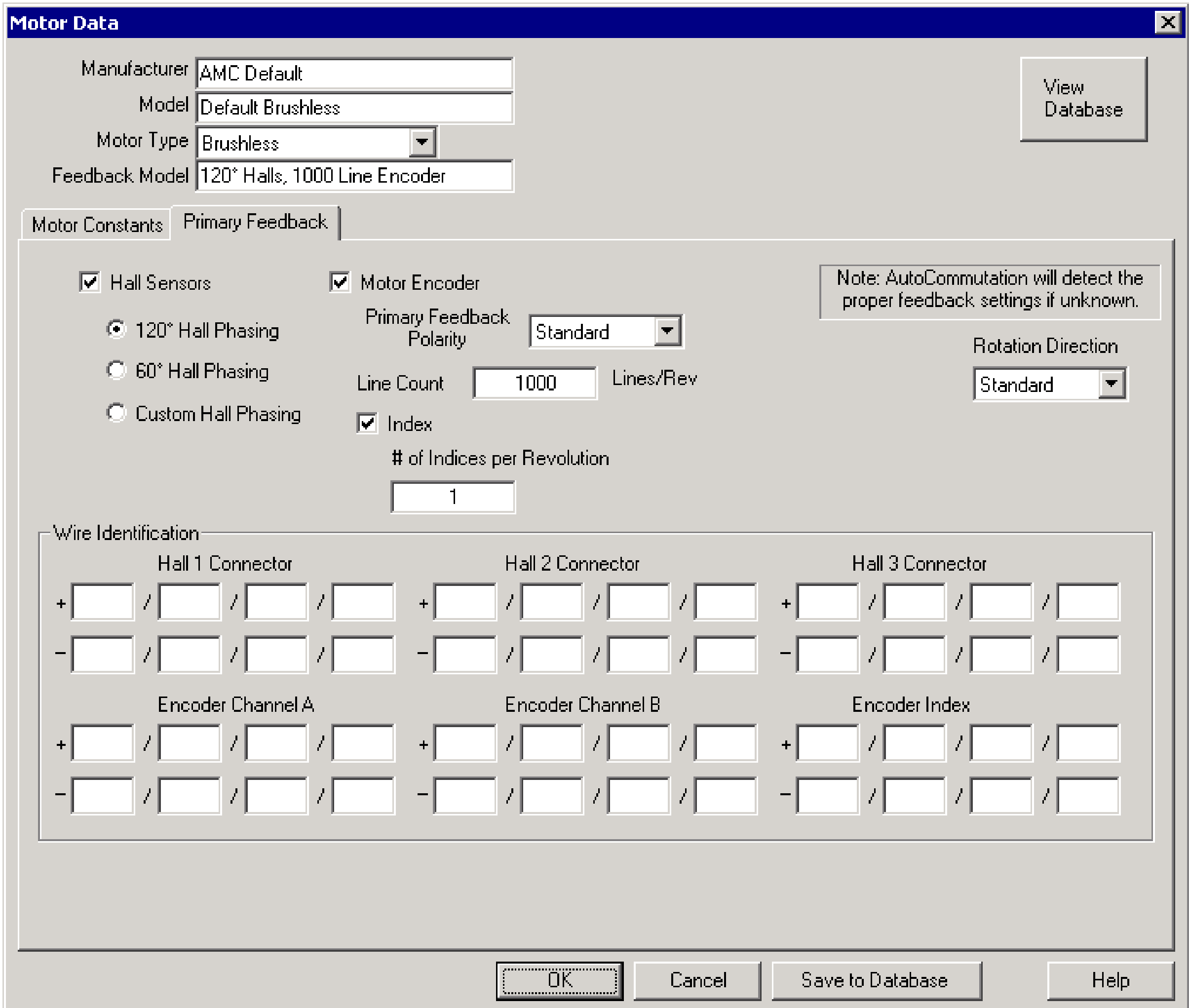
### *Motor Constants*



- Under the Motor Constants tab, the following information can be entered:

| | |
|---|---|
| Voltage Constant | The voltage constant corresponds to the motor back-EMF constant. This value can be obtained from the motor data sheet. The numerical value and units can be selected independently (the numerical value will NOT be re-calculated when a different unit is selected). |
| Torque/Force Constant | This value can be obtained from the motor data sheet. The numerical value and units can be selected independently (the numerical value will NOT be re-calculated when a different unit is selected). |
| Resistance | This value can be obtained from the motor data sheet. In case of brushed type motors it corresponds to the armature resistance. In case of brushless motors it corresponds to the phase-to-phase resistance. |
| Inductance | This value can be obtained from the motor data sheet. In case of brushed type motors it corresponds to the armature inductance. In case of brushless motors it corresponds to the phase-to-phase inductance. |
| Thermal Time Constant | This value can be obtained from the motor data sheet. |
| Max Motor Temperature | Maximum allowable motor temperature. |
| Maximum Current | The maximum current is the peak operating current that the motor can handle. This does not correspond to the de-magnetizing current, which is typically much higher than the maximum operating current. This value can be obtained from the motor data sheet. |
| Rated Current | The rated current is the nominal (continuous) current that the motor can handle. This value can be obtained from the motor data sheet. |
| Number of Poles/Pole Pitch | The number of poles, in case of rotary motors, corresponds to twice the number of electrical cycles per motor revolution. The pole pitch, in case of linear motors, corresponds to the length of one electrical cycle (360 degrees). The numerical value and units can be selected independently (the numerical value will NOT be re-calculated when a different unit is selected). This information can be obtained from the motor data sheet. |
| Maximum Speed | The maximum speed corresponds to the maximum speed of the motor. The numerical value and units can be selected independently (the numerical value will NOT be re-calculated when a different unit is selected). This information can be obtained from the motor data sheet. |
| Maximum Current At Max Velocity | Corresponds to the maximum current the motor can handle at maximum speed. This information can be obtained from the motor data sheet |
| Wire Identification | Wiring identification can be entered for each phase, by selecting wire color(s) and/or wire labels |

## Primary Feedback



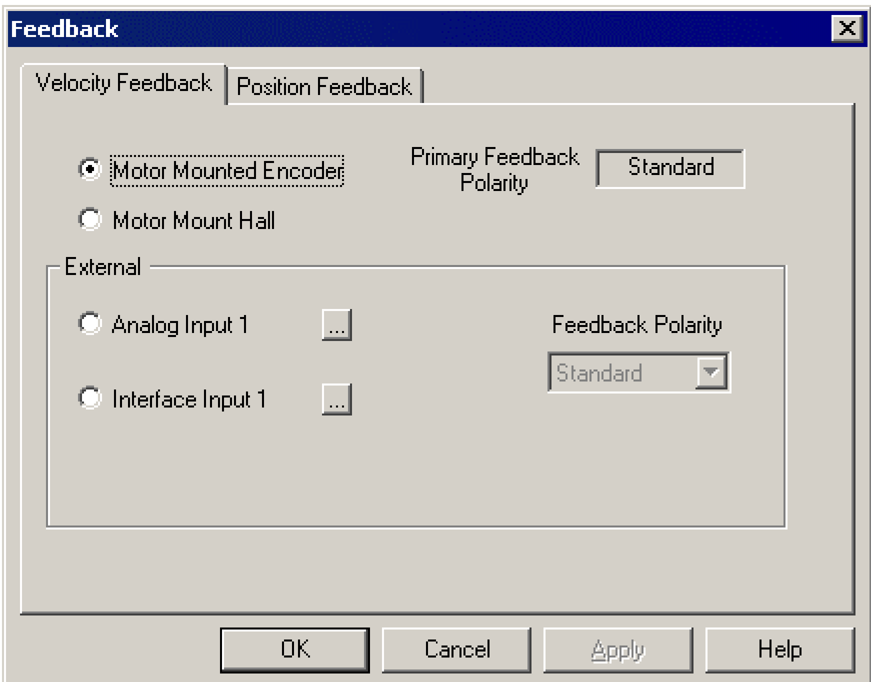
- Under the Primary or Commutation Feedback tab, the following data can be entered (model dependent):

| | |
|---|---|
| Hall Sensors | Check the box if Hall sensors are available and connected. Also select the Hall phasing. |
| Motor Encoder | Check the box if a motor mounted encoder is connected. AutoCommutation™ Detection will determine the polarity. Enter the encoder line count per revolution (per mm/inch for linear motor). Also indicate if there is an encoder index pulse, and the number of index occurrences per revolution (number of lines per index occurrence for linear motor). |
| Wire Identification | Wiring identification can be entered for each connection, by selecting wire color(s) and/or wire labels |
| In case of resolver feedback, you may also select the resolution (12-bit means an equivalent 4096 counts/rev, 14-bit means 16384 counts/rev). | |

## *Feedback*

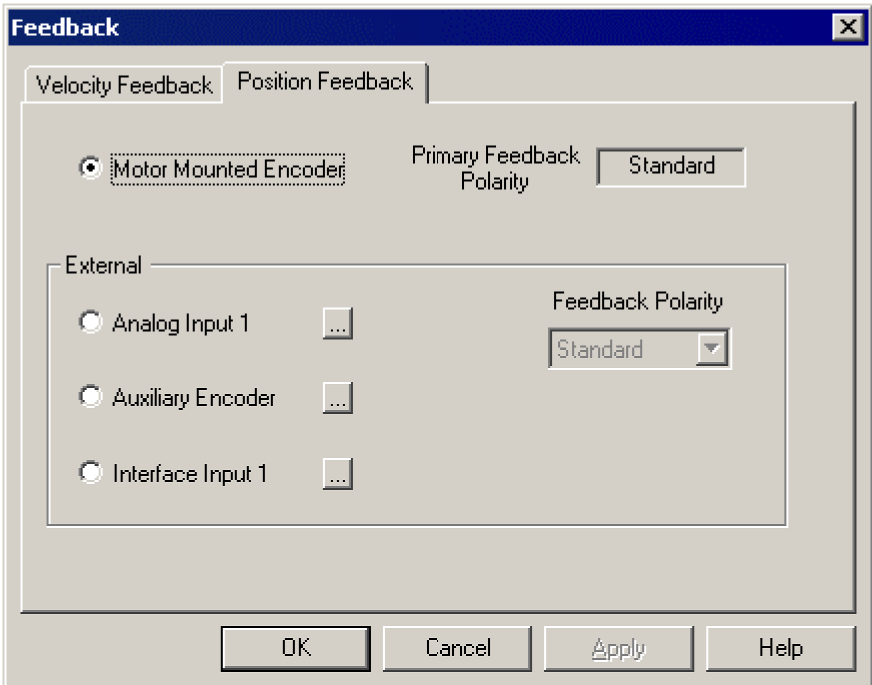
The Feedback window is opened by clicking on the feedback icon in the main block diagram. It allows selection of the feedback used by the velocity and position loops.

### Velocity Feedback




- **Motor Mounted Encoder:** the velocity is derived from the motor mounted encoder.
- **Motor Mount Hall:**the velocity is derived from the motor mounted hall sensors.
- **Analog Input:** the velocity is derived from an analog input. Typically used in case of a motor mounted tachometer. The analog signal must be conditioned not to go outside the range of +/-10V. For drive with multiple analog inputs, click on the ... to select which analog input to use.
- **Interface Input:** the velocity is provided over the communication interface. This is an advanced option which is currently not available with standard drives.
- **Resolver:** the position is derived from the motor mounted resolver.
- **Feedback Polarity:** Represents the polarity of the selected feedback device signal.

## Position Feedback




- **Motor Mounted Encoder:** the position is derived from the motor mounted encoder.
- **Analog Input:** the position is derived from an analog input. Typically used in case of a load-mounted potentiometer. The analog signal must be conditioned not to go outside the range of +/-10V. For drive with multiple analog inputs, click on the  to select which analog input to use
- **Auxiliary Encoder:** the position is derived from the auxiliary encoder input. Click on the  to specify the ratio of input counts to position counts.
- **Interface Input:** the position is provided over the interface.
- **Resolver:**the position is derived from the motor mounted resolver
- **Feedback Polarity:** Represents the polarity of the selected feedback device signal.

- Note: availability of the above selections is drive model dependent.

### *Drive Configuration*

The Drive Configuration window allows configuration of general drive parameters. These limits have associated events (see Drive Status and Drive Control). The following tabs are available:

Drive Current Limits

Voltage Limits

Velocity Limits

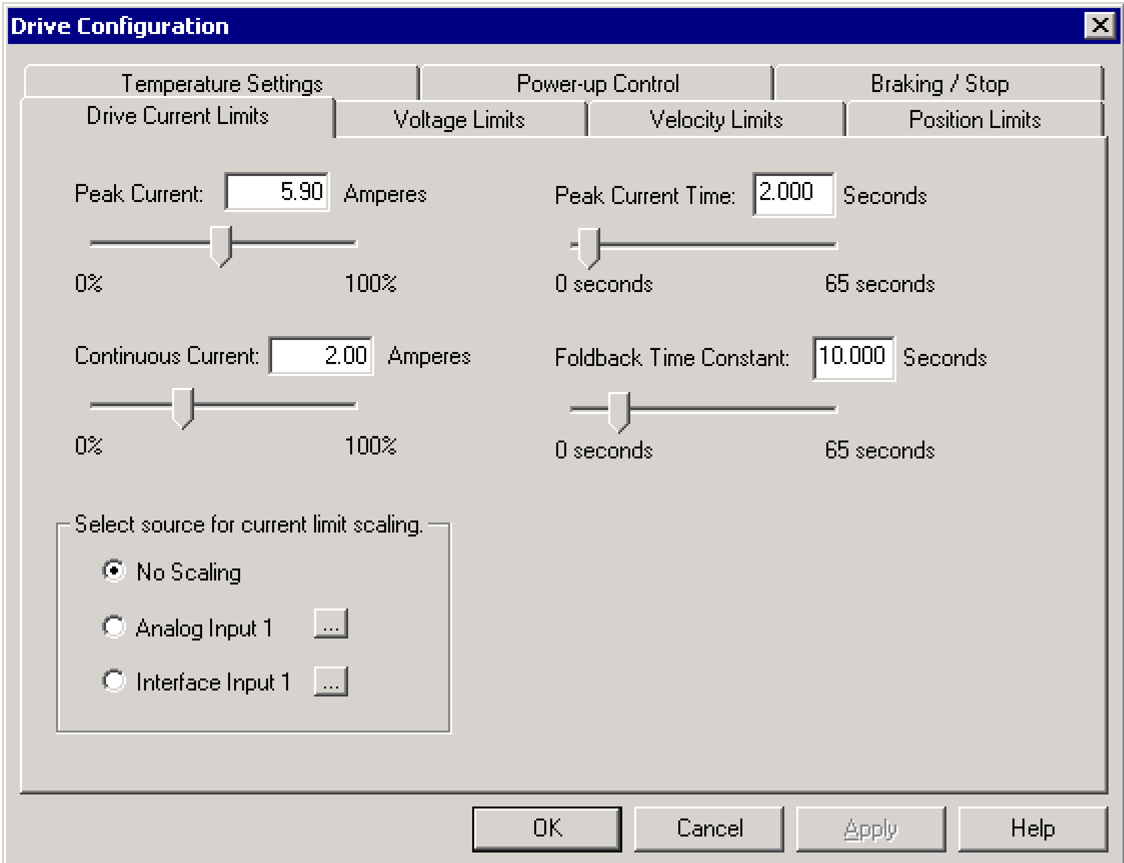
Position limits

Temperature Settings

Power-up Control

Braking

### *Drive Current Limits*

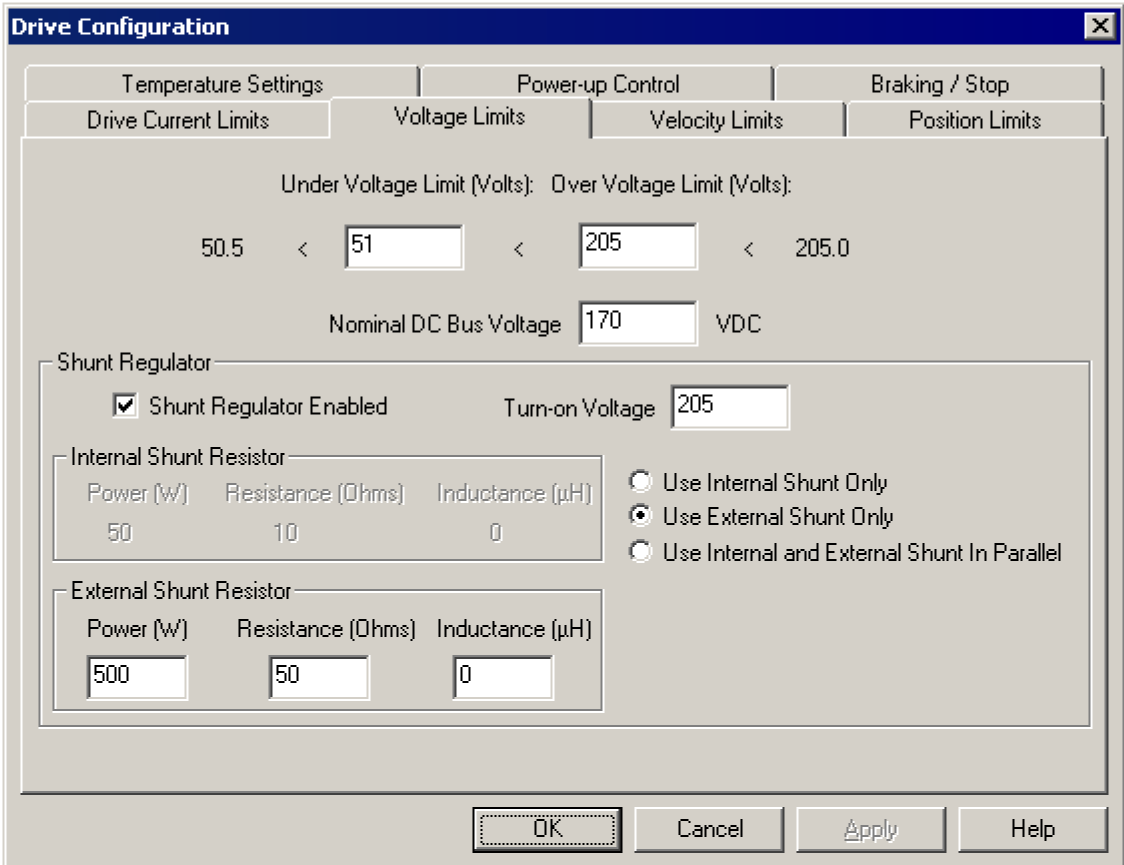



Sets the drive output current limits, within the hardware capabilities of the drive.

- **Peak Current**: Maximum output current (limited output time).
- **Continuous Current**: The maximum continuous current level the drive will output.
- **Peak Current Time**: The maximum time duration of peak current.
- **Foldback Time Constant**: The time the drive will use to reduce the current to the continuous current level setting.
- **Current Limit Scaling**: You may assign an input to change the current limit dynamically. The scaling value can be adjusted in IO Configuration.

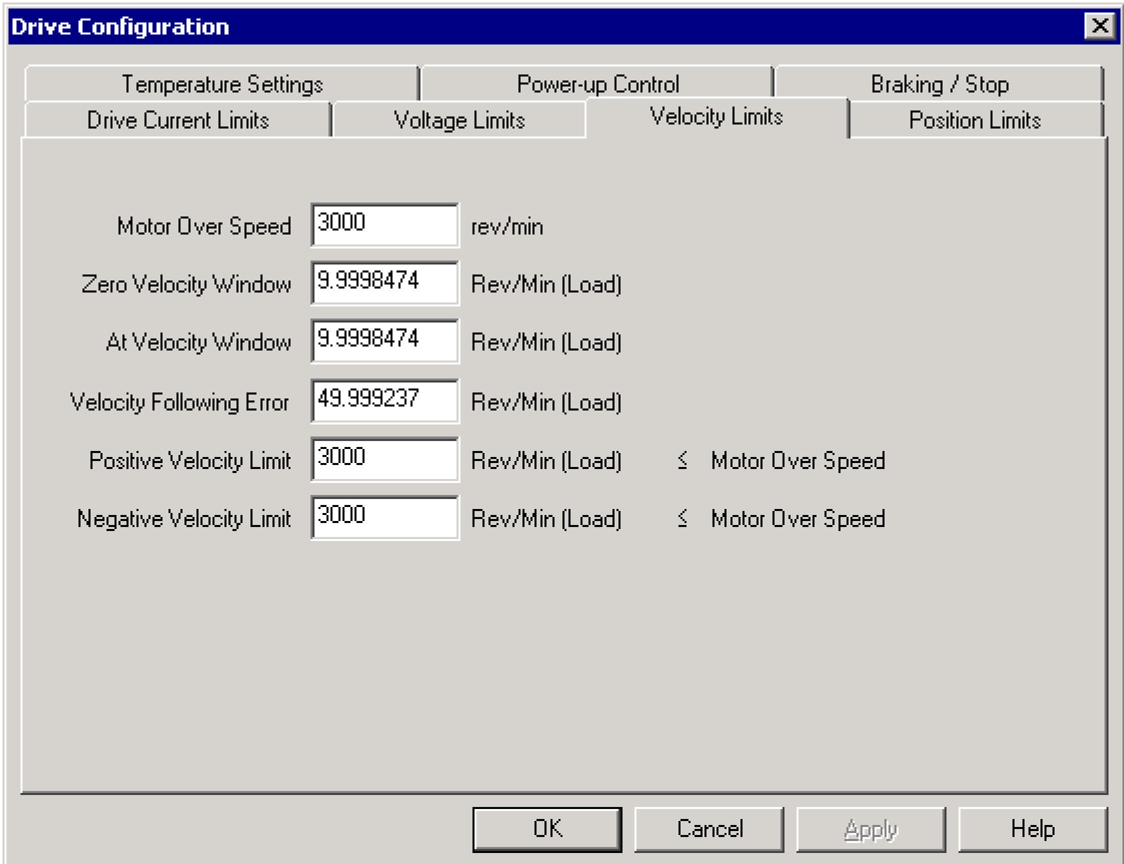
The drive can output its rated peak current for a maximum of 2 seconds with a foldback time of 10 seconds. This defines the maximum current capability curve. Current profiles that intersect with the maximum current capability curve will be limited to stay within this envelope.

### *Voltage Limits*




- Sets the user under and over voltage limits. These limits are restricted to fall within the hardware capability of the drive. The Nominal DC Bus Voltage should contain the normal operating DC voltage supplied to the drive. If using an AC input drive, the Nominal DC Bus voltage is equal to the AC voltage multiplied by 1.41.
- If the drive has provision for connection of an external shunt resistor, the parameters of that resistor can be entered. If that provision is not available, these fields will not be available. Check the data sheet for your drive to see if an external shunt resistor can be connected.
- The shunt regulator (if available, depending on drive model) can be enabled/disabled and its turn-ON voltage can also be set. The internal shunt-resistor parameters, if present, are displayed.

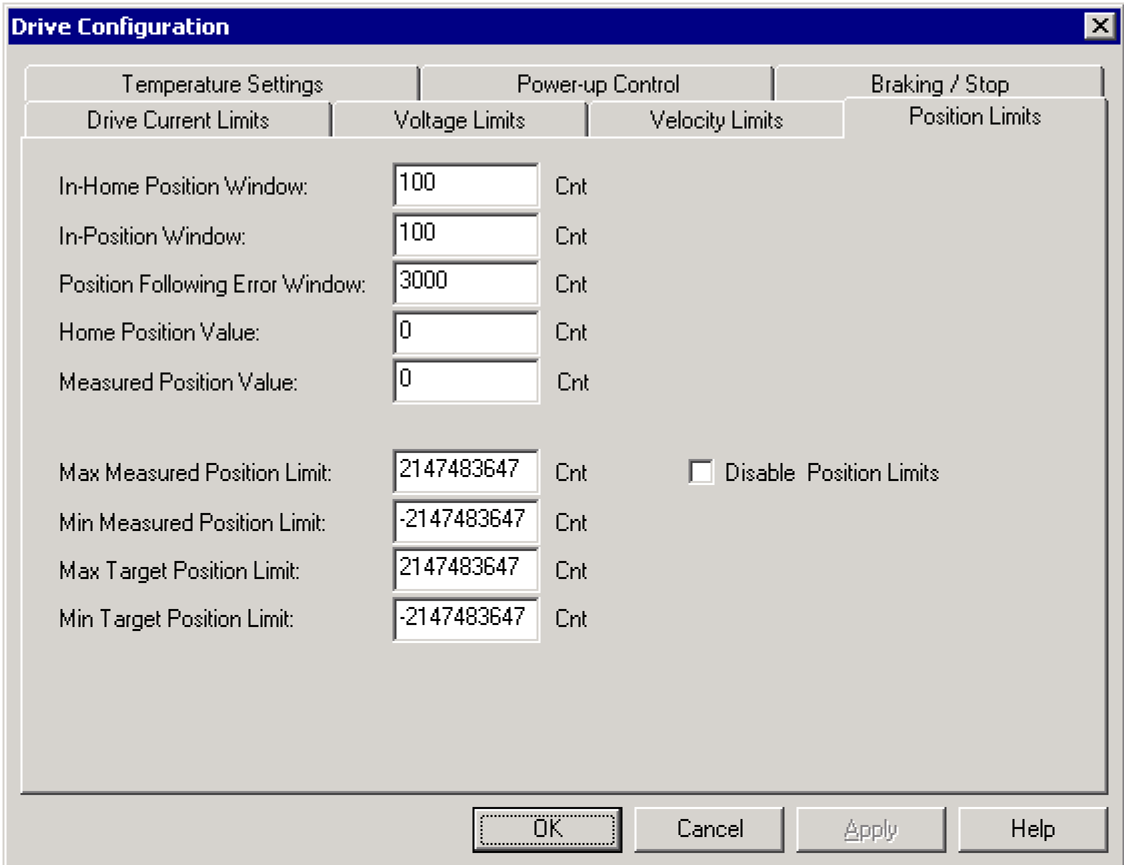
### *Velocity Limits*




The following velocity-related limits can be set:

- **Motor Over Speed**: The maximum speed in which the motor should be able to go. The action following a motor overspeed event can be defined in Drive Control. (Active in all operating modes)
- **Zero Velocity Window**: The measured velocity values, within which the motor is considered to be at zero velocity (active in all operating modes)
- **At Velocity Window**: The “At Velocity” event will be set when the measured velocity reaches the target velocity, within the “At Velocity” window (active in velocity mode only).
- **Velocity Following Error**: The maximum allowed velocity error (difference between demand velocity and measured velocity), prior to setting the “Velocity Following Error” event (active in velocity mode only).
- **Positive Velocity Limit**: The maximum allowed demand velocity in the positive direction (active in velocity mode only).
- **Negative Velocity Limit**: The maximum allowed demand velocity in the negative direction (active in velocity mode only).

### *Position limits*



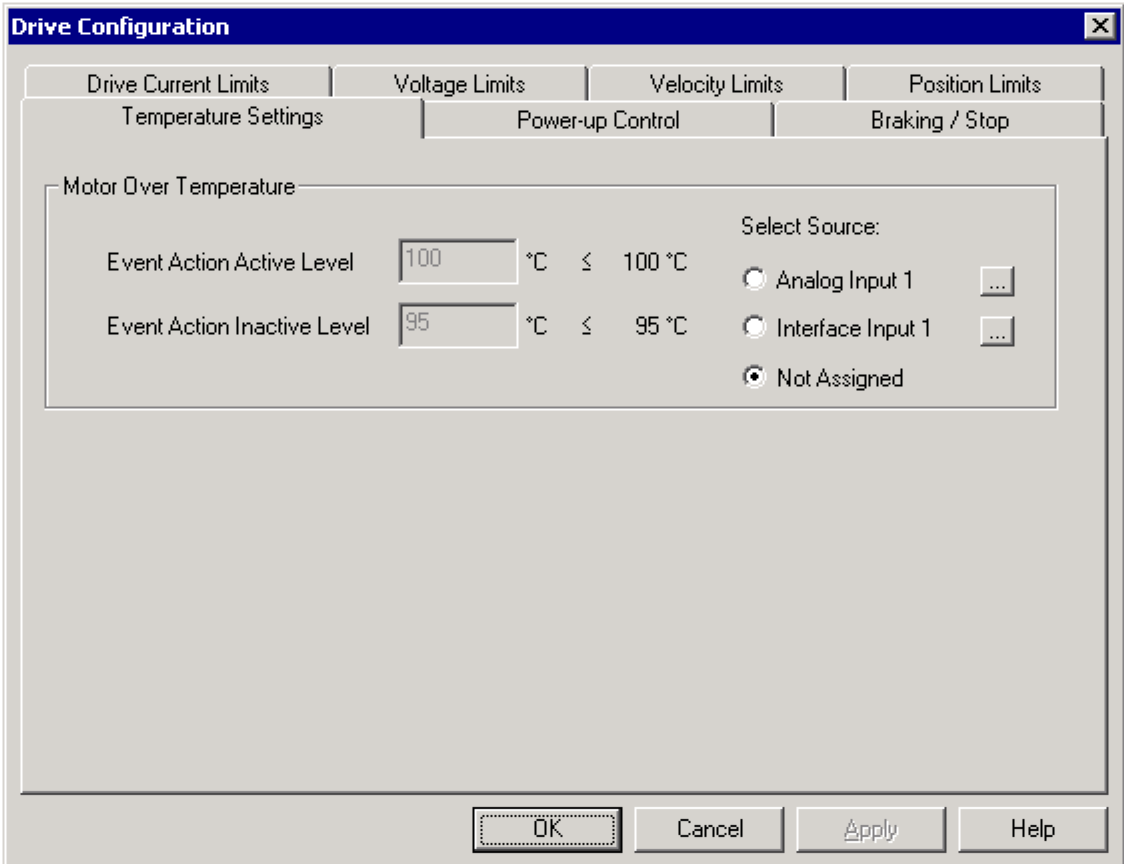

The following position-related limits can be set:

- **In-Home Position Window**: Defines a window around the Home Position Value, such that when the measured position is within this window, the At-Home Position event will be active.
- **In-Position Window**: Defines a window around the target position, such that when the measured position is within this window, the At Command event will be active.
- **Position Following Error Window**: The maximum allowed position error (difference between demand position and measured position) prior to setting the “Position Following Error” event (active in position mode only).
- **Home Position Value**: Position value of the home position. When the measured position reaches this position, within the In-Home Position Window, the At-Home event becomes active.
- **Measured Position Value**: Replacement value for the measured position when the Load Measured Position event is triggered. This allows you to redefine the current measured position (e.g. reset to zero). ***CAUTION: make sure the target***

***position is set to the proper value prior to enabling the drive. Otherwise a large position following error will exist.***

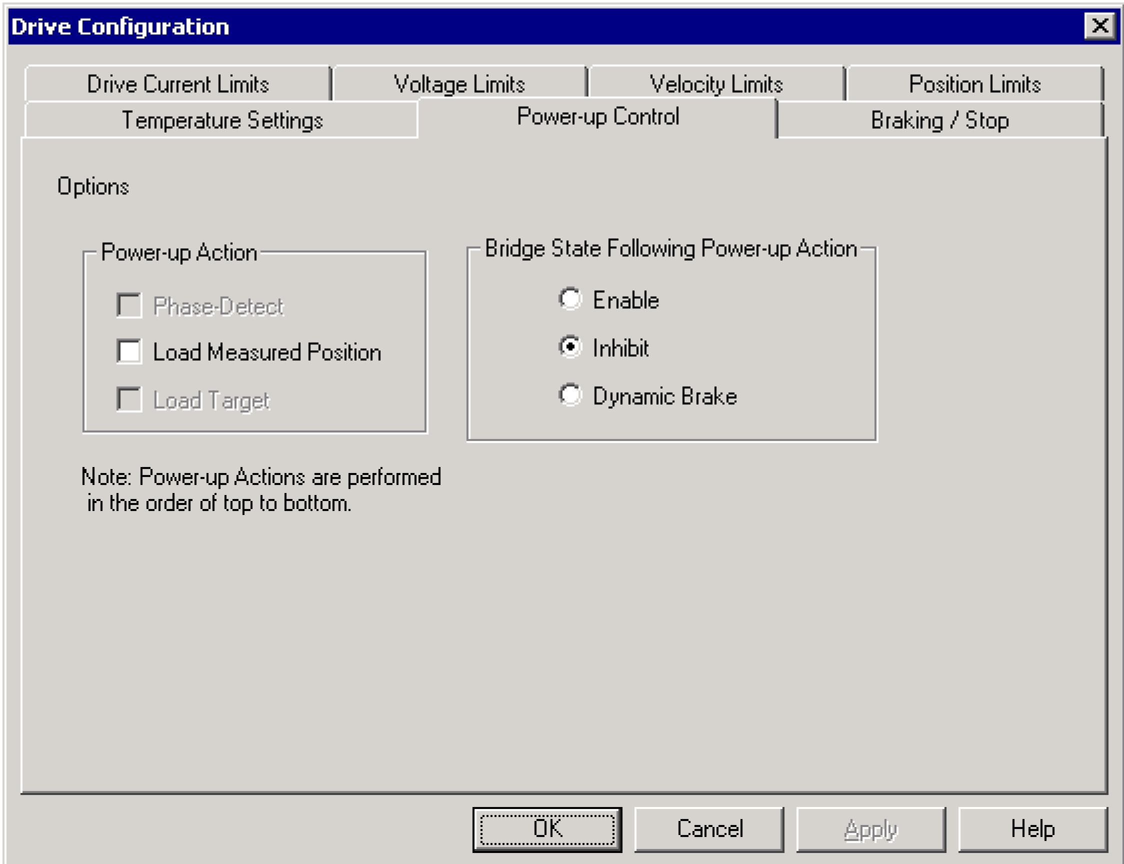
- **Max Measured Position Limit**: Maximum allowed measured position. The Max Measured Position event will become active if the measured position exceeds this value.
- **Min Measured Position Limit**: Minimum allowed measured position. The Min Measured Position event will become active if the measured position exceeds this value.
- **Max Target Position Limit**: Maximum allowed target position. The Max Target Position event will become active if the target position exceeds this value.
- **Min Target Position Limit**: Minimum allowed target position. The Min Target Position event will become active if the target position exceeds this value.
- **Disable Position Limits Checkbox**: Allows you to disable position limits so the motor has no maximum or minimum position value.

### *Temperature Settings*




- If the motor has an analog temperature sensor, it can be connected to an analog input of the drive. The user can configure a maximum allowable motor temperature at which point the drive will be disabled. The motor temperature level at which the drive can be re-enabled can also be configured. The source of the analog input can be configured as well. For a digital temperature sensor, see I/O Configuration.

### *Power-up Control*



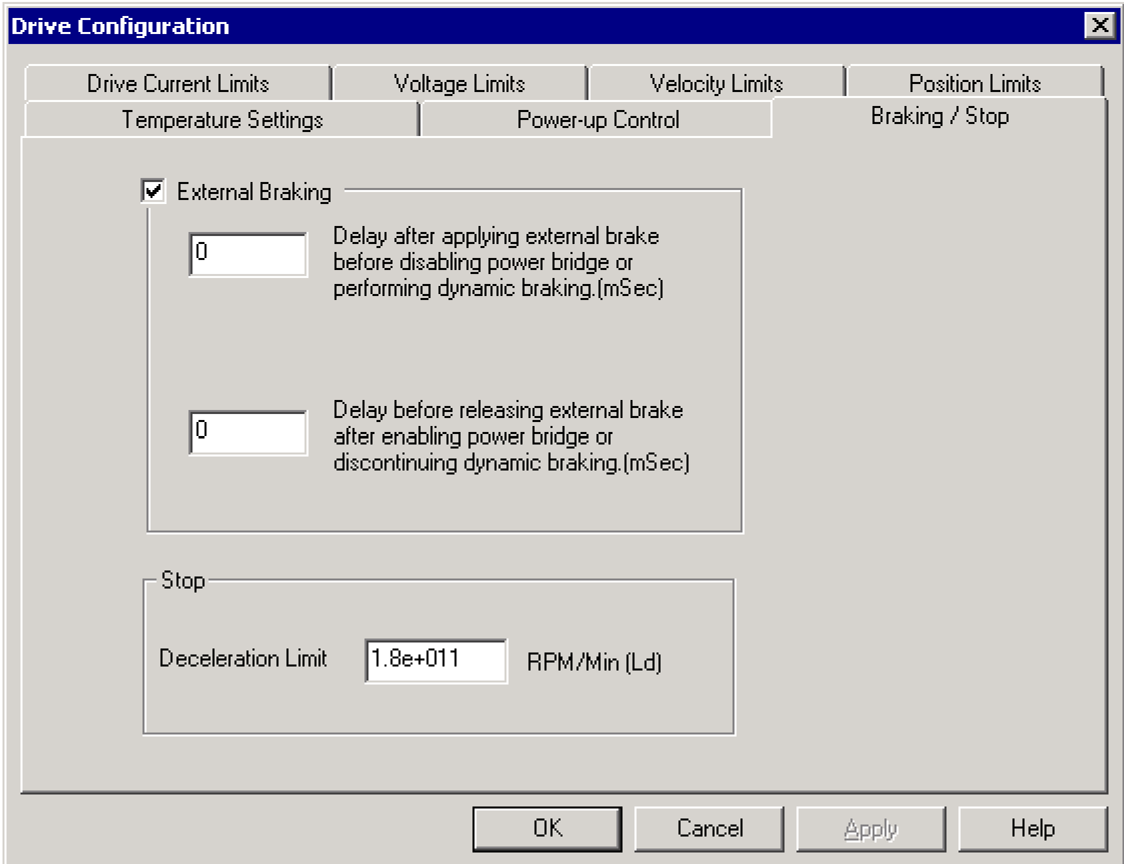

Power-up Action

- **Phase Detect**: Performs a phase-detect routine on start-up. The event is only active when using an encoder with no hall feedback.
- **Load Measured Position**: Loads the position defined in the position limits tab as home position.
- **Load Target**: Loads the target position as defined in the Command Source window. This action is only active when operating in Encoder Following or Step and Direction position mode.

Bridge State Following Power-up Action

- Note: If *Inhibit* or *Dynamic Brake* is selected, you will only be able to enable the drive using the software. To use inhibit or dynamic brake via digital inputs, see I/O Configuration.

### *Braking*




- **Braking**: Allows you to set time delays between external braking and enabling/inhibiting the drive. This is particularly important in applications which the motor is holding a vertical load. The delay allows the brake to apply before the bridge is disabled or for the brake to release after the bridge is enabled. You may configure events to activate the brake output from within Drive Control.
- **Stop**: When active, the Stop will decelerate the load to a stop and send a zero command to the active loop. Events that trigger the Stop function can be configured in Drive Control.

## Tuning and Commutation

Drive tuning is a multi-step process that involves proper tuning of up to three different servo loops. Before tuning, the drive should have the appropriate parameters and limits configured as per the Drive Parameter Configuration page. Follow the steps below for tuning and commutating your drive and motor.

**Caution: Sudden motion may occur! Tuning should only be performed after motor information and drive limits have been specified. See** Drive Parameter Configuration **if you are not sure your drive is configured correctly for tuning.**

**Step 1**: Current Loop Tuning: Once the drive parameters are configured properly, the current loop must be tuned. This is the innermost loop and forms the basis of all motion. You can select to have the current loop gains calculated based on motor and application data. This will typically provide a good starting point where most applications will require further refinement of the tuning parameters. Make sure the drive is disabled before hitting **Calculate Gains**.

**Step 2:** AutoCommutation™ Detection: This routine collects data on the motor and feedback parameters and asks the user to verify that they match what is entered into the Motor Data page. **It is crucial to make sure the motor is unloaded; any load applied to the motor will skew the results of the routine**. Some applications may have motors that cannot perform this routine due to mechanical constraints. It is possible to manually wire a motor for commutation. See Manual Commutation Procedure if you must perform manual commutation.

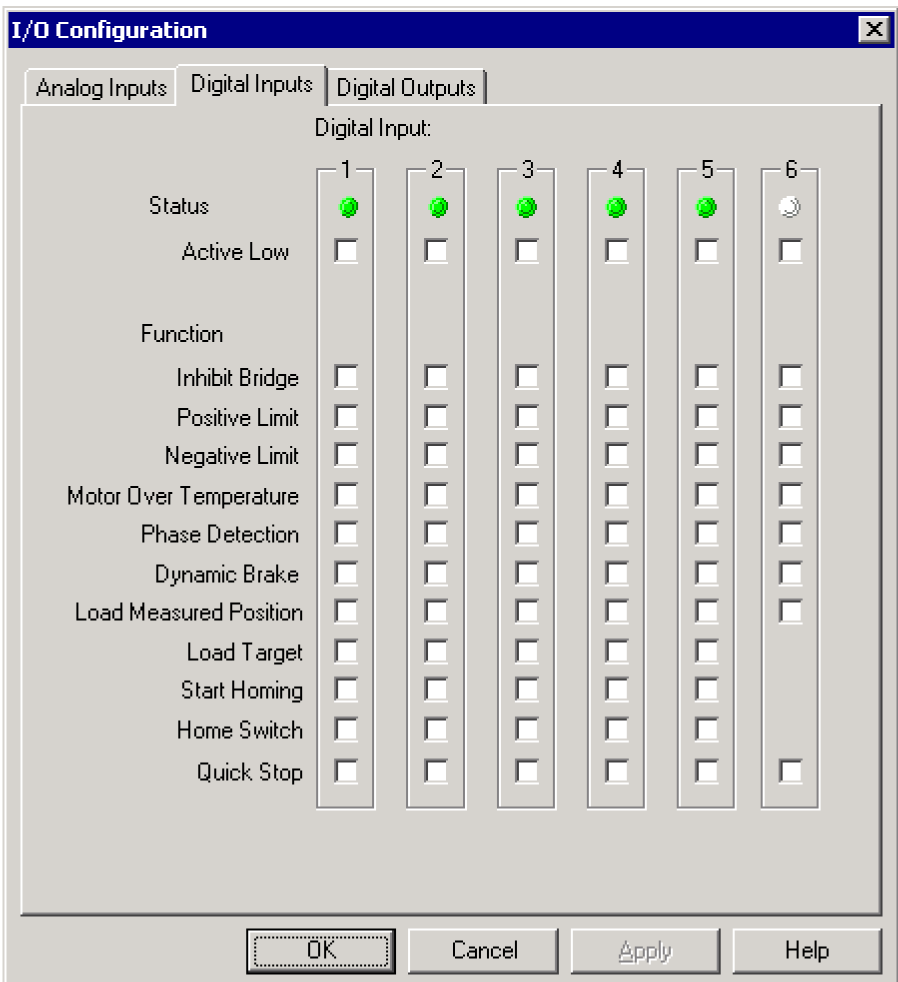
**Step 3: Velocity Loop Tuning:** If you want to operate the drive in velocity mode, you must tune the current loop and setup the drive to commutate the motor (steps 1 and 2). A very tight current loop inside of a relatively tight velocity loop may cause audible white noise. If maximum bandwidth is not necessary, de-tuning the current loop usually removes most of the audible noise. The velocity loop will have to be adjusted any time the curent loop tuning is changed.

**Step 4**: **Position Loop Tuning:** You can either tune the position loop around the velocity loop, or around the current loop. Generally, it is much easier to tune a position loop around a velocity loop because only the proportional gain is needed. When tuning position around the current loop, a high derivative gain may be necessary on top of both proportional and integral gains.

### *Current Loop Tuning*

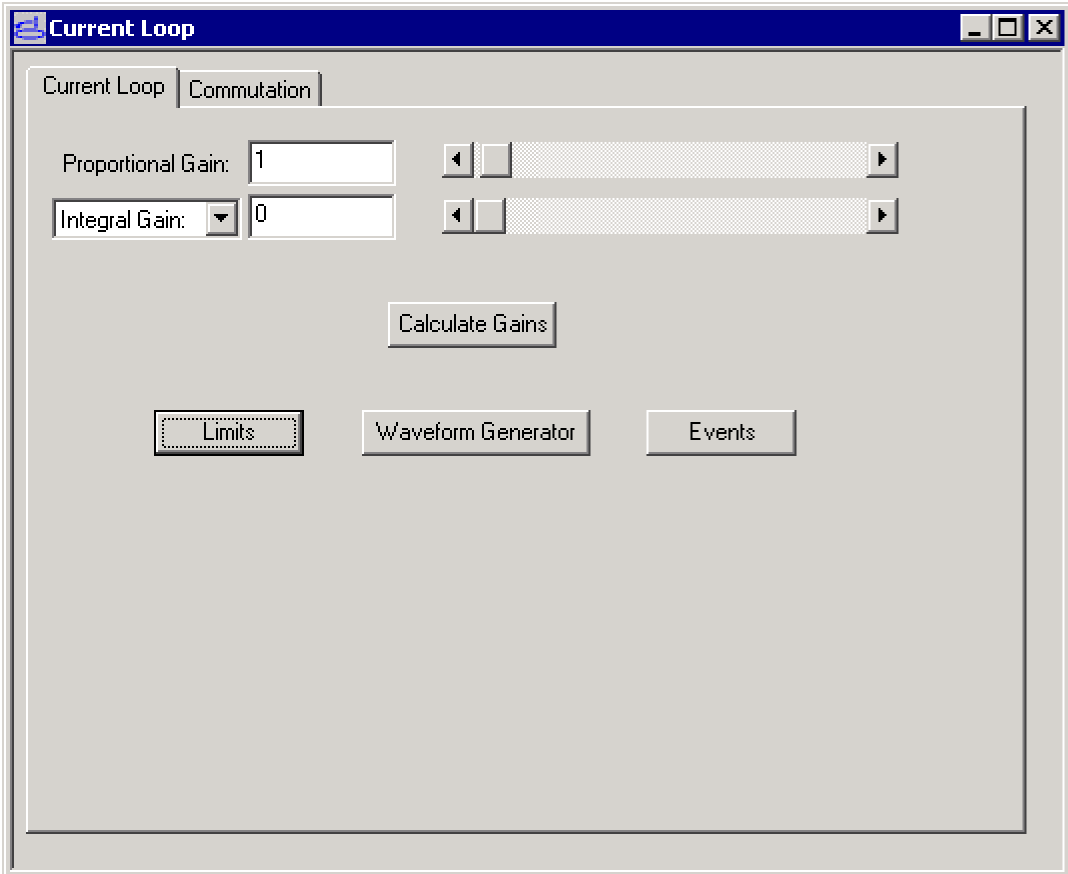
**Caution: make sure that the motor is free to move and de-coupled from the load. Sudden motion may occur!**
**Tuning of the current loop should only be performed after motor information and drive limits have been specified.**

**Step 1: I/O Configuration Set Up**




1. Click the I/O Configuration Block in the main block diagram
2. Select the Digital inputs tab
3. If an external Inhibit/Enable circuit is used during setup, use the check boxes to assign the inhibit function and proper polarity (e.g. active high or active low).
4. If no external Inhibit/Enable circuit is used during setup, clear check boxes for all inhibits. Inhibit/Enable will be controlled solely through the DriveWare Enable/Disable Drive icon .

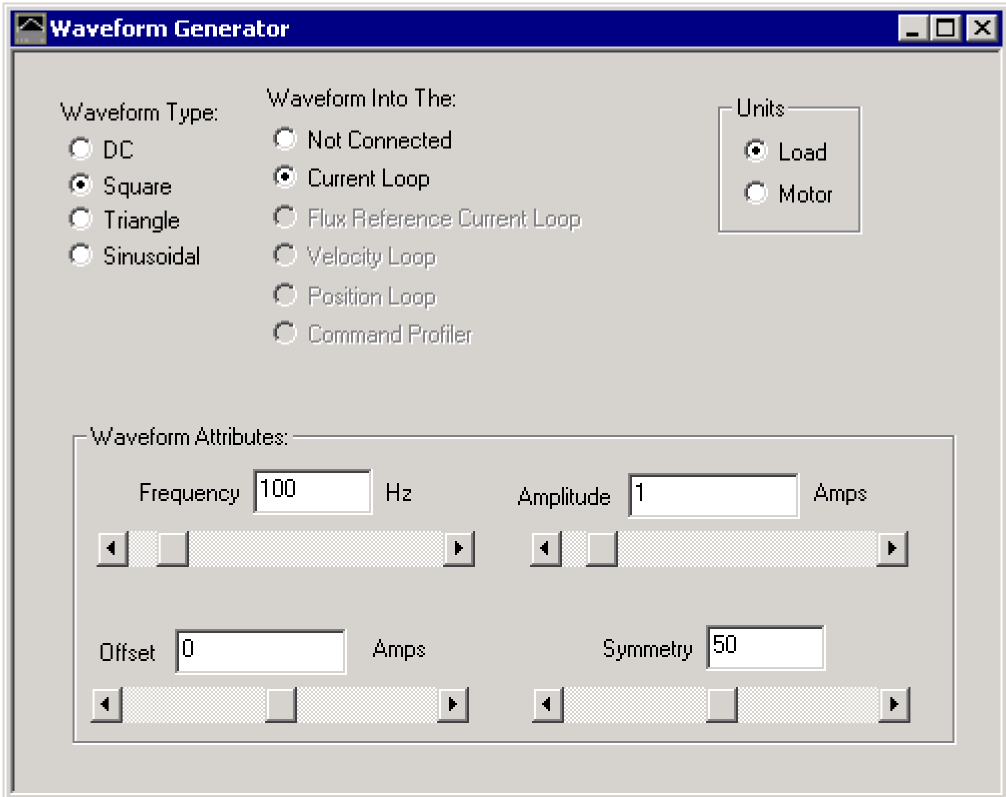
**Step 2: Current Loop Window Set Up**




1. On the Main Block Diagram, click Current Loop to open the current loop tuning parameters.
2. To set starting values for proportional and integral gains, click the *Calculate Gains* button.

**Note:** *Calculate Gains* utilizes the values entered into the Motor Data and Primary Feedback and Drive Configuration screens. The specified inductance, resistance, and bus voltage determine accuracy of the calculated values. If accurate data is not available, begin with the Proportional Gain = 1 and Integral Gain = 0.

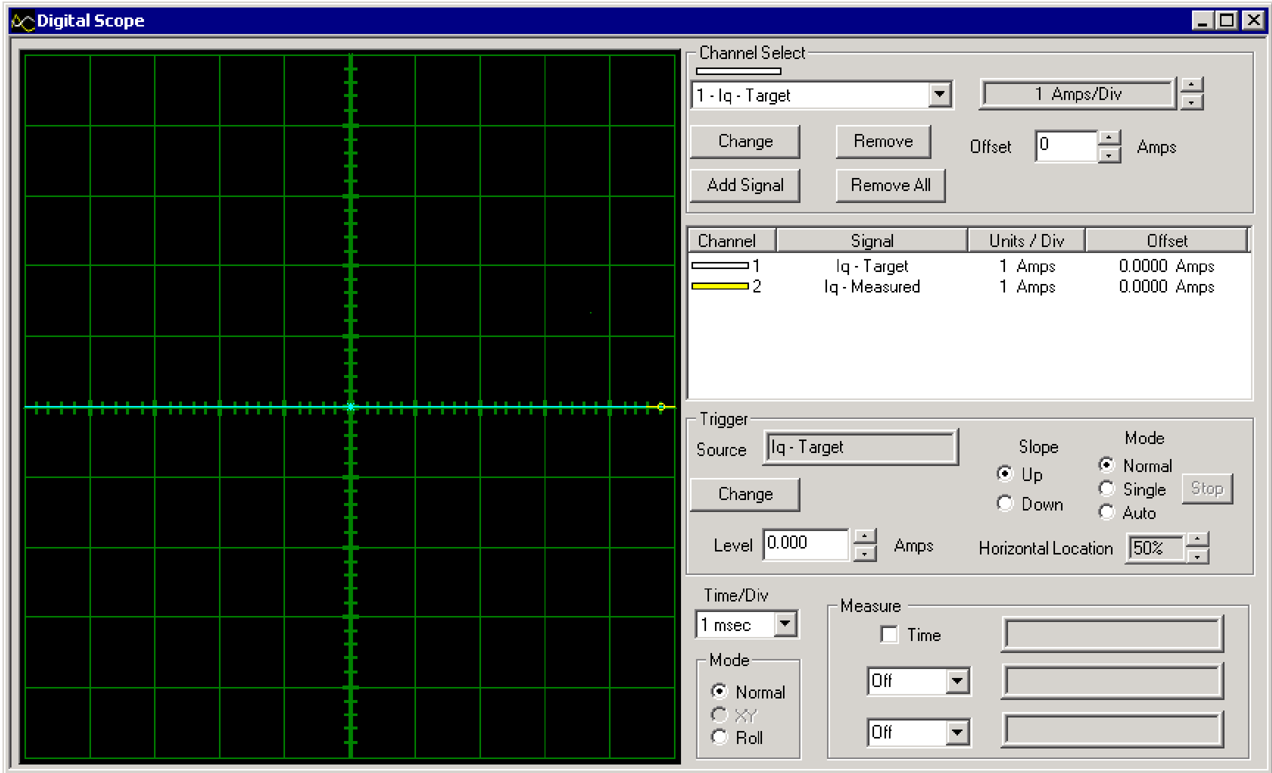
### Step 3: Waveform Generator Set Up




In the Current Loop window, click the Waveform Generator button (or select Tools --> Waveform Generator on the menu bar) to open the Waveform Generator screen. Set up the Waveform Generator as follows.

1. Select the *Square* Waveform Type.
2. Set *Frequency* to 100 Hz. If your motor has low inertia and is very responsive, use 150 Hz or 200 Hz.
3. Ensure *Offset* is zero.
4. Ensure *Symmetry* is 50%.
5. Select *Waveform Into The Current Loop*.
6. Set the waveform amplitude to an appropriate value. Begin with 10% of the drive continuous rating or 50% of the motor continuous current rating, whichever is lower.

## Step 4: Oscilloscope Set Up

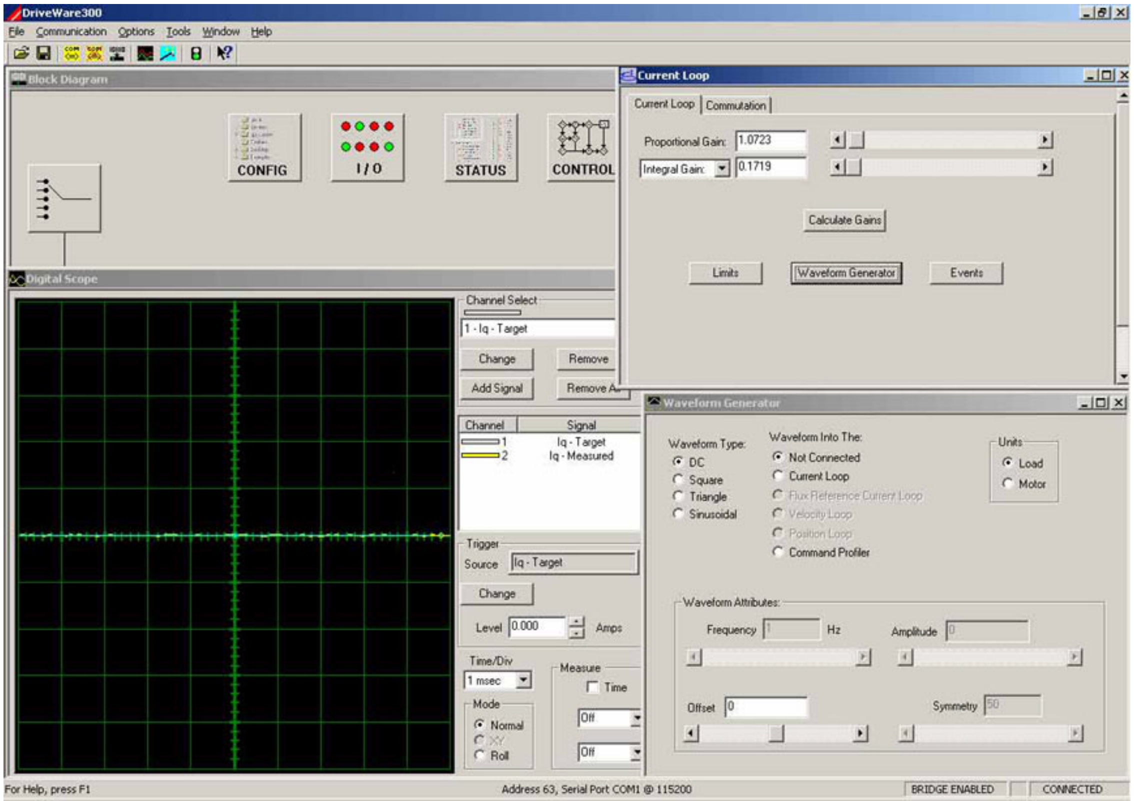



On the menu bar, select Tools --> Oscilloscope (or click the oscilloscope icon on the toolbar ) to open the digital oscilloscope. Set up the scope view as follows.

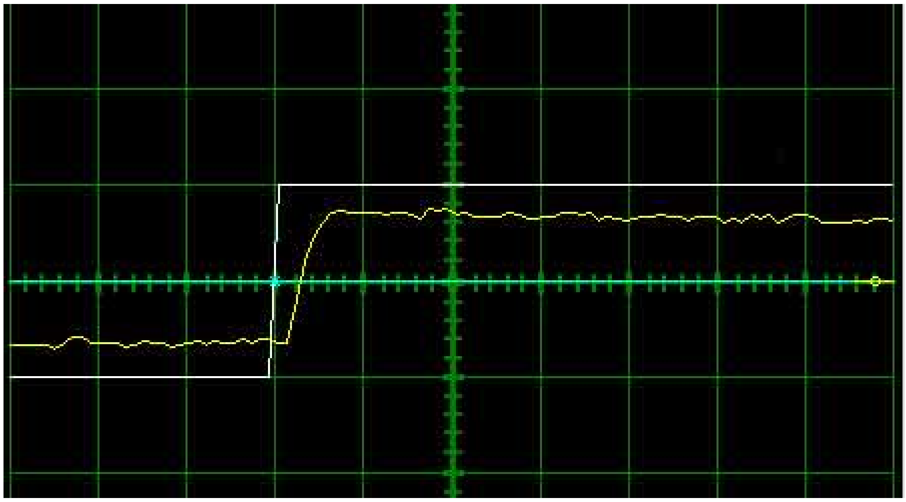
1. Assign the channel 1 signal to **Iq-Target** and the channel 2 signal to **Iq-Measured** (use the "Change" button if necessary).
2. Change the Trigger Source to Torque Target with the Level set to zero.
3. Ensure Trigger Mode is Normal.
4. Change Time/Div to either 1 msec or 500 usec.

## Step 5: Tuning

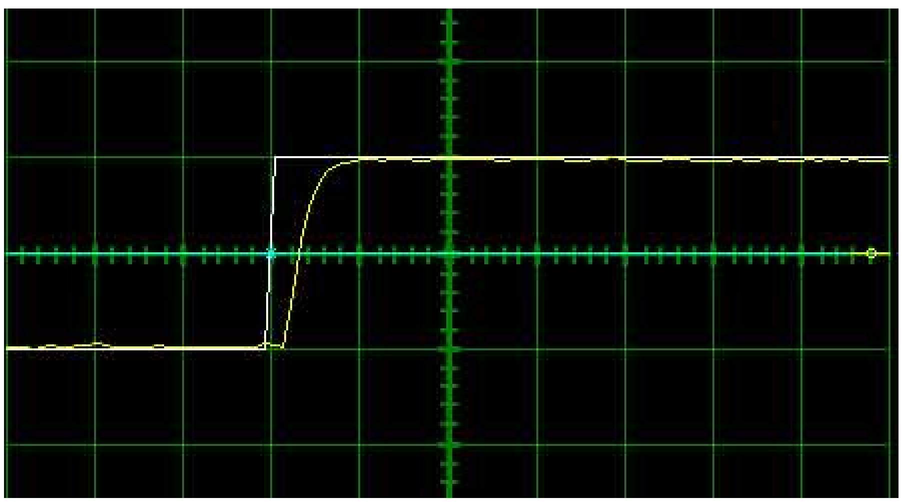
Position the Scope, Waveform Generator, and Current Loop windows such that a majority of all the windows are visible as shown. The best method is to place the oscilloscope in the lower left corner, while placing the current loop and Waveform Generator windows in the upper and lower right corners as shown below.




- Enable the drive by clicking the Enable/Disable Drive icon 
- Proper current loop tuning starts with zero integral gain while increasing the proportional gain until a 'knee' is formed (with no overshoot) in the Iq-Measured trace as shown below.



- At this point, the proportional gain is done and the Integral gain must be slowly increased to close the steady state error between the Iq-Target and Iq-Measured traces. See below.



- Tuning changes with signal amplitude. Therefore you should now re-adjust the current amplitude in the waveform generator according to your most common application current requirements and re-tune. Contouring applications generally use small signal transients while Point-to-point applications use larger signal transients.
- Disable the drive by clicking the Enable/Disable Drive icon .
- When current loop gain adjustments are complete, click **Not Connected** on the Waveform Generator to remove the command signal from the drive.
- On the Menu Bar, select Communication --> Store (or click the Store Settings icon  ), then OK to store parameters to the drive nonvolatile memory.

### *Commutation*

Motor commutation is dependant on the type of motor and feedback available from the motor. Brushed motors have a commutator built into the motor housing; therefore the drive does not have to be configured to commutate them. Brushless DC (Trapezoidal), and AC (Sinusoidal), motors require a correctly configured drive to commutate. There are two ways to configure an AMC Digiflex drive to commutate a motor.

- AutoCommutation™ Detection : Most applications can use the autocommutation routine for configuring a drive to a specific motor. This routine will detect the feedback devices attached to the motor and ask the user to verify them against the motors data sheet.

- Manual Commutation Procedure: If your motor is mechanically restrained such that it is not free to move 2 revolutions + 1 electrical cycle in both directions, or 3 electrical cycles for a Brushless linear motor, you will have to perform the Manual Commutation method. This method is just as precise, but can be more tedious.

### *AutoCommutation™ Detection*

Commutation of a permanent magnet servomotor is the process that maintains an optimal angle between the permanent magnet field and the electromagnetic field created by the motor current(s). The AutoCommutation routine detects the motor feedback type and polarity, then configures the drive commutation parameters appropriately. This process ensures optimal torque or force generation at any motor speed for brushless motors.

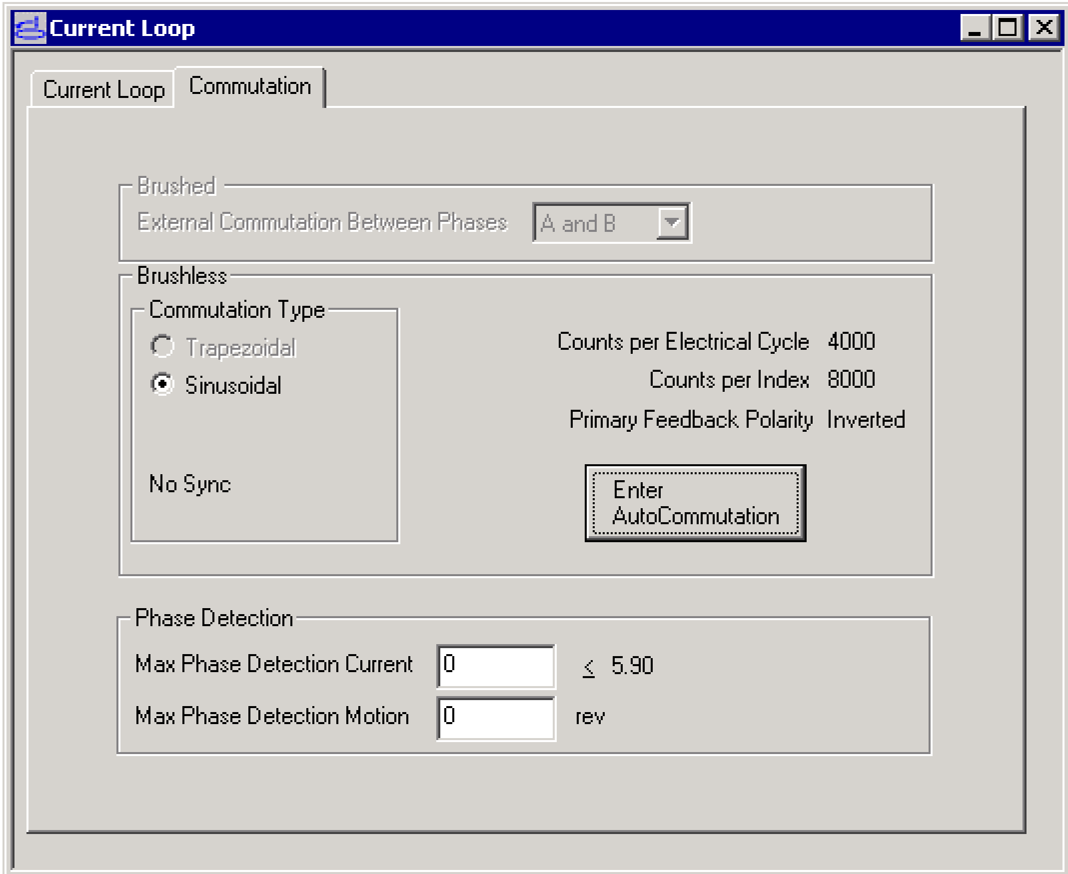
Brushless and linear motors with insufficient travel distance (two revolutions plus one electrical cycle for rotary motors, or three electrical cycles for linear motors), will require the Manual Commutation Procedure instead. AutoCommutation detection is not required for brush-type motors.

**Before you run Auto Commutation, be sure you have:**

- **Entered in the correct motor information in the motor data page**
- **Specified the correct feedback information**
- **Specified limits to protect the motor**
- **Tuned the current loop**
- **De-coupled the motor from any load and secured the motor. Sudden motion will occur!**

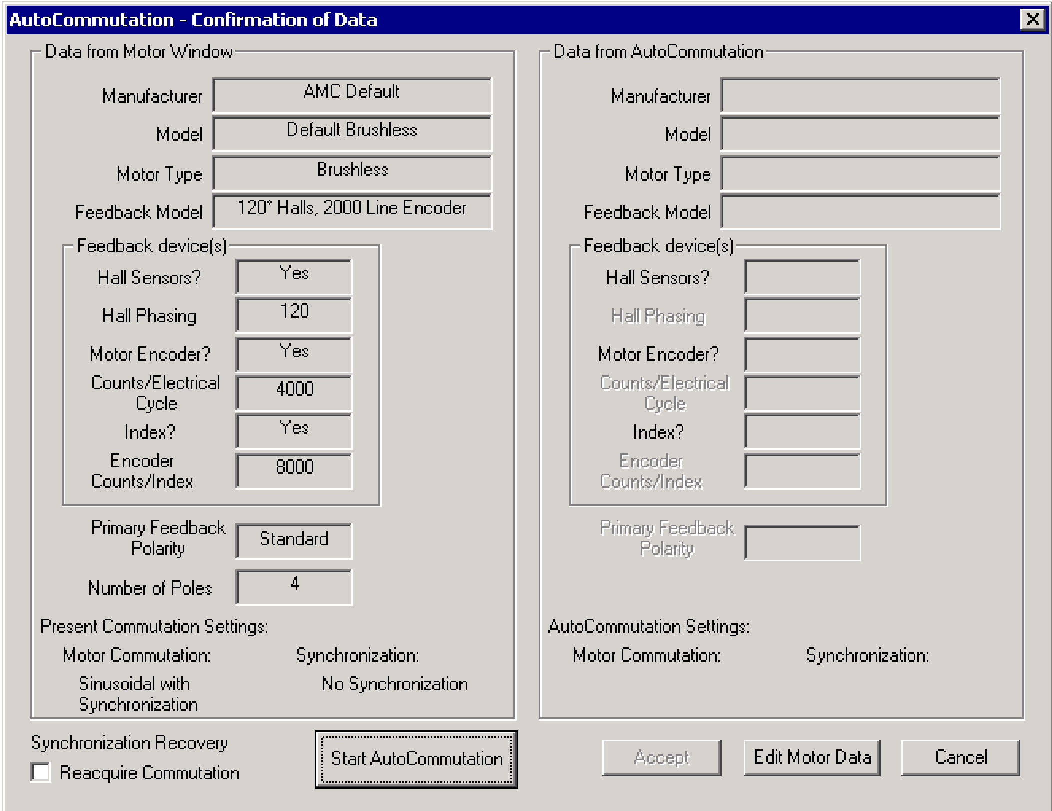
If you have not done the preceding, see the Steps Before Operating Your Drive page.

For brushless and linear motors with sufficient travel distance, proceed as follows:




1. In the current loop window, select the *Commutation* tab.
2. Ensure *Sinusoidal Commutation* is selected.
3. Verify that indicated *Counts per Electrical Cycle* and *Counts per Index* values are correct. (The primary Feedback Polarity will be determined during Auto Commutation)
4. If drive is disabled, click the Enable/Disable Drive icon  to enable the drive.

5. Click *Enter AutoCommutation* to open the Commutation Data window.




6. Ensure the *Reacquire Commutation* checkbox is checked*.
7. Click *Start Auto Commutation* to begin the process. During the Auto Commutation process, monitor the distance traveled in each direction. Rotary motors will turn two revolutions plus one electrical cycle in each direction. Linear motors will move three electrical cycles in each direction.
8. When Auto Commutation is complete, select whether the motor has moved the proper distance ("Yes") or has not moved the proper distance ("Edit Motor Data"). If the motor did not move the proper distance, verify the pole count or pole pitch in the motor data window. Click OK in Motor Data to return to the Auto Commutation window.
9. Select the appropriate mode of commutation synchronization. For motors with hall sensors and encoder feedback, select Sinusoidal With Synchronization and select Hall Edge for the synchronization signal. Click OK. For motors using encoder with index channel only or resolver, select *Sinusoidal with Synchronization* and select *Encoder Index* for the synchronization signal. Click OK.
10. In some cases, the Auto Commutation results will slightly differ from Motor Data (e.g. Counts/Electrical Cycle, Counts/Index). In those cases, you may choose between using the value determined by Autocommutation or the value from Motor Data (Use Value). Typically, it is recommended to use the value from motor data.
11. Click Accept to apply the Auto Commutation parameters.

12. On the Menu Bar, select *Communication* --> *Store* (or click the Store Settings icon ), then OK to store parameters to nonvolatile memory.

**Note:** For brushless motors with encoder only feedback, the Phase Detection function must be utilized whenever power to the drive is cycled or a loss of sinusoidal commutation occurs. See Phase Detection .

*The *Reacquire Commutation* checkbox ensures that the commutation settings will be corrected if there is a synchronization error.

### *Manual Commutation Procedure*

The large majority of applications do not require this method for configuring a drive to commutate the motor. A much easier method is provided in the setup software called AutoCommutation. The procedure for manual commutation is somewhat tedious but no less accurate than the autocommutation method.

Commutation of a permanent magnet servomotor is the process that maintains an optimal angle between the permanent magnet field and the electromagnetic field created by the motor current(s). This process ensures optimal torque or force generation at any motor speed for brushless motors. Because some applications cannot use our Autocommutation method, each drive defaults to a standard switching sequence that will commutate one of the six motor phase wiring combinations for a given feedback wiring configuration. Follow the steps below to find the correct motor phase wiring to commutate your motor.

**Before you perform manually commutation, be sure you have:**

- **Entered in the correct motor information in the motor data page**
- **Specified the correct feedback information**
- **Specified limits to protect the motor**
- **Tuned the current loop**
- **De-coupled the motor from any load and secured the motor. Sudden motion will occur!**

**Setting Over Speed Limits**

1. Go to Drive Configuration--> Velocity Limits tab, set the maximum speed you wish the motor to spin for this test. Set this fairly high but not so fast it is dangerous if the motor spins away.
2. Go to Drive Control--> Velocity Events, set the *Motor Over Speed* event action to *Disable Power Bridge* and *Unlimited Recoveries*.

**Performing manual Commutation**

1. Ensure *Trapezoidal Commutation* is selected in the Current Loop > Commutation tab.
2. Verify that indicated *Counts per Electrical Cycle* and *Counts per Index* values are correct. Ignore the *primary feedback polarity.*
3. Make sure the feedback device is wired correctly and connected to the drive as per the drives data sheet.
4. Create a table like this one on a piece of paper: (Use your motor's wire colors)

| Combination # | Motor Phase Colors | Results |
|---|---|---|
| 1 | red, white, blue | |

| | | |
|---|---|---|
| 2 | red, blue, white | |
| 3 | blue, red, white | |
| 4 | blue, white, red | |
| 5 | white, blue, red | |
| 6 | white, red, blue | |

5. If drive is enabled, click the Enable/Disable Drive icon to issue a Commanded Inhibit and disable the drive.
6. Check the Drive Status window for any faults or user inhibits, and take corrective action to clear them. The Commanded Inhibit should remain applied. Some faults in the Drive Status block are harmless and do not disable the drive, ignore these.
7. In the drive setup software, open the Waveform Generator and setup a DC waveform into the current loop with an offset of 10% of the rated continuous motor current. Ensure that Commanded Inhibit is still applied at this point.
8. Wire the motor phases according to each combination and perform the following procedure:

- Use the icon to enable the drive. Always be ready to disable the drive in case of spin away or other dangerous situation.

- If the motor attempts to spin away, disable the drive, change the polarity of current in the waveform generator and enable again to see if the drive spins away in the opposite direction. The motor should demonstrate smooth torque of the same magnitude in both directions. If torque is smooth for both directions, mark a "good" in the results column and try the next combination.

- If the motor does not spin, carefully nudge it to see if it will begin spinning. In this case either the current is too low or the commutation angle is incorrect. Try increasing the current magnitude in small increments until either the motor spins or you reach 25% of continuous current. If the motor does not spin with increased current, or spins only after help is applied, mark a "bad" in the results column. Reset the current to 10% and try the next combination.

- If the motor spins faster in one direction than the other, mark a bad in the results column and try the next combination

- If none of the combinations yields a good result, contact AMC.

- When finished, click **Not Connected** on the Waveform Generator to remove the command signal from the drive

You should only find one combination that smoothly turns the motor in both directions with strong torque; use this wiring combination. If using *Trapezoidal Commutation*, this procedure is finished. If using *Sinusoidal Commutation*, ensure it is selected in the Current Loop > Commutation tab before moving on.

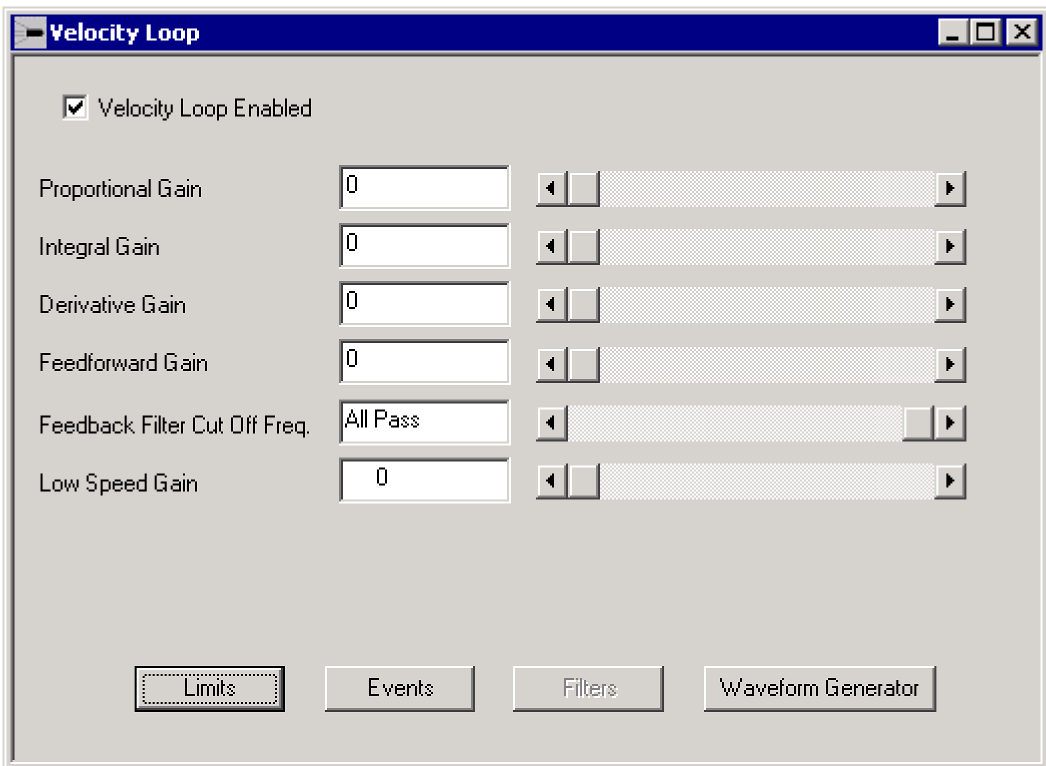
Go back to Drive Configuration --> Velocity Limits, and set the desired *Motor Over Speed*. Go back to Drive Control --> Velocity Events and configure the desired event action for your application. On the Menu Bar, select Communication --> Store (or click the Store Settings icon  ), then OK to store parameters to the drive nonvolatile memory. The drive is now ready either for tuning the outer loops, or final commissioning and use.

## *Velocity Loop Tuning*

Velocity loop tuning is dependant on the mechanical load, and therefore will change with any mechanical system changes. Velocity loop tuning should be performed with the motor installed in the system and connected to the load.

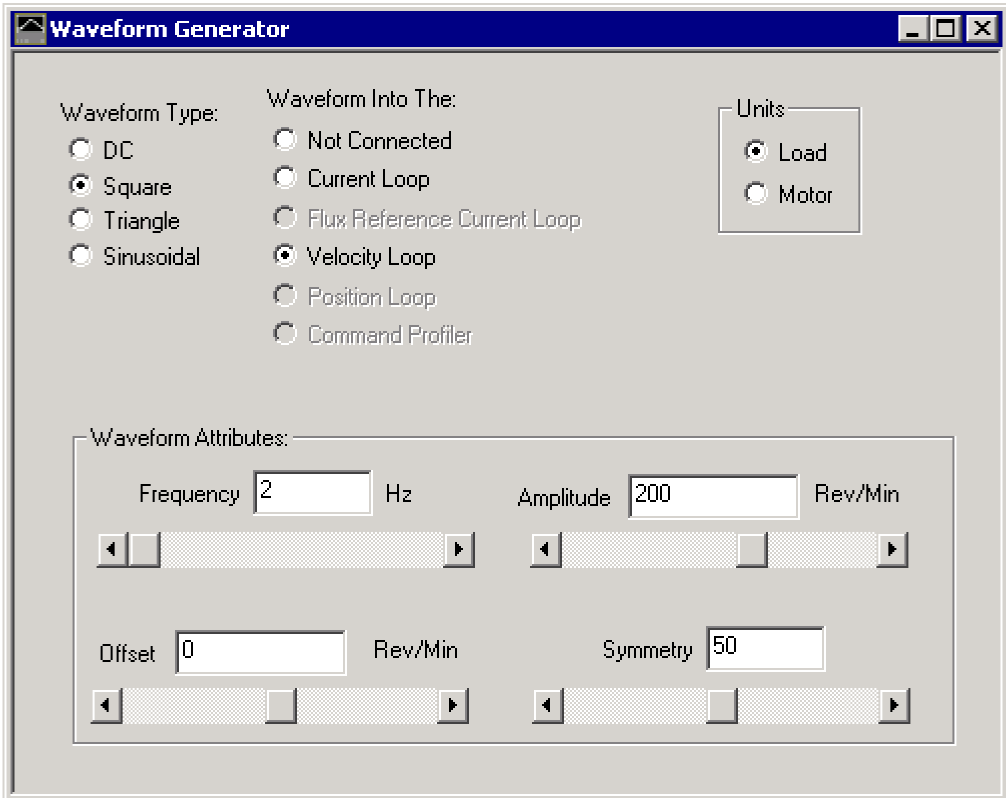
**Caution: Make sure that the load is free to move and coupled to the motor. Sudden motion may occur!**
**Tuning of the velocity loop should only be performed after current loop tuning and motor commutation.**

### Step 1: Velocity Loop Window Set Up




1. Verify the drive is disabled
2. From the Main Block Diagram, open the Velocity Loop window and check the "velocity loop enabled" checkbox.
3. Set the *Proportional*, *Integral*, Derivative, *Feedforward*, and *Low Speed* gains to zero. Set the *Feedback Filter Cut Off Freq*. all the way to the right until it says All Pass.

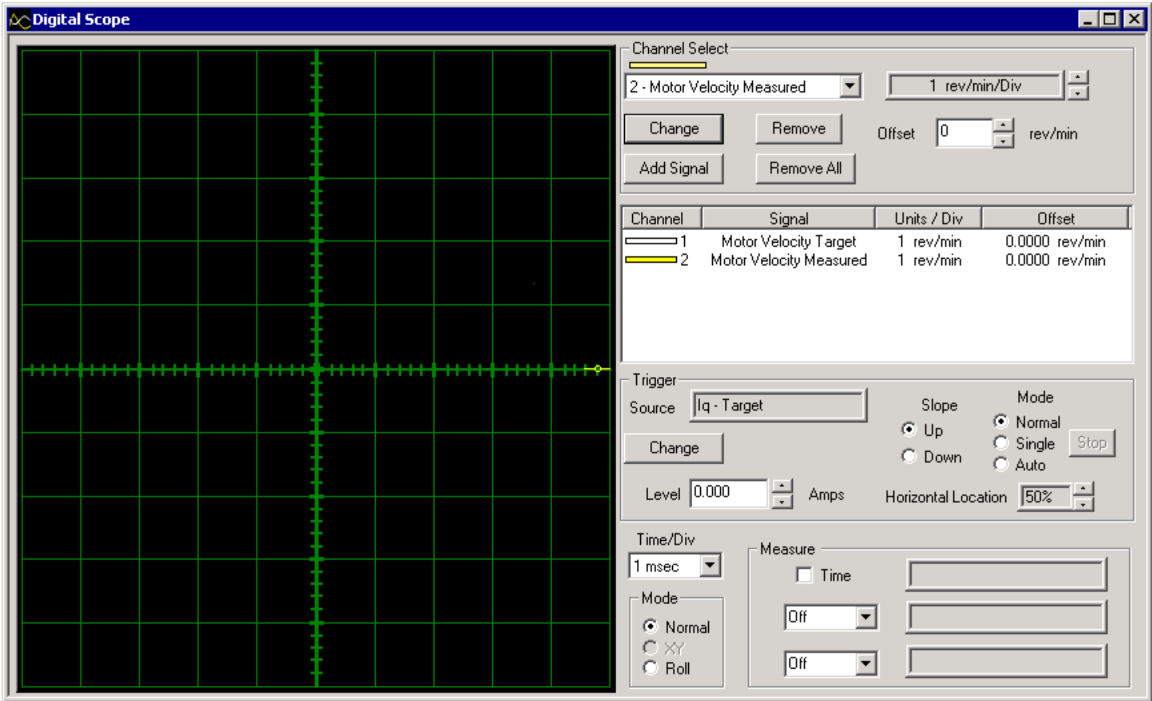
## Step 2: Waveform Generator Set Up




In the velocity loop window, click the Waveform Generator button (or select Tools --> Waveform Generator on the menu bar) to open the Waveform Generator screen. Set up the Waveform Generator as follows.

1. Select the *Square* Waveform Type.
2. Set *Frequency* to around 2-3 Hz. The Frequency should be slow enough to achieve commanded velocity, but fast enough to prevent the system from reaching a mechanical limit.
3. Ensure *Offset* is zero.
4. Ensure *Symmetry* is 50%.
5. Select *Waveform Into The Velocity Loop*.
6. Set the waveform amplitude to approximately 10% of motor nominal speed.

### Step 3: Oscilloscope Set Up

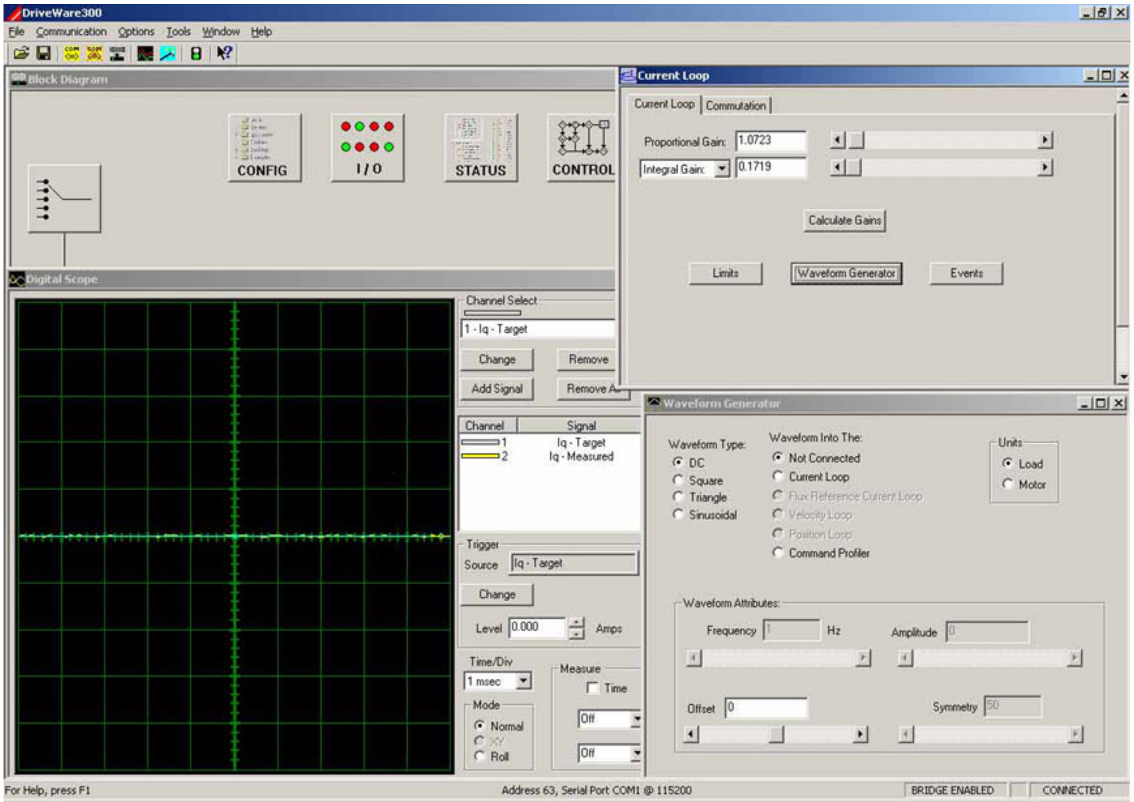



Set up the scope view as follows:

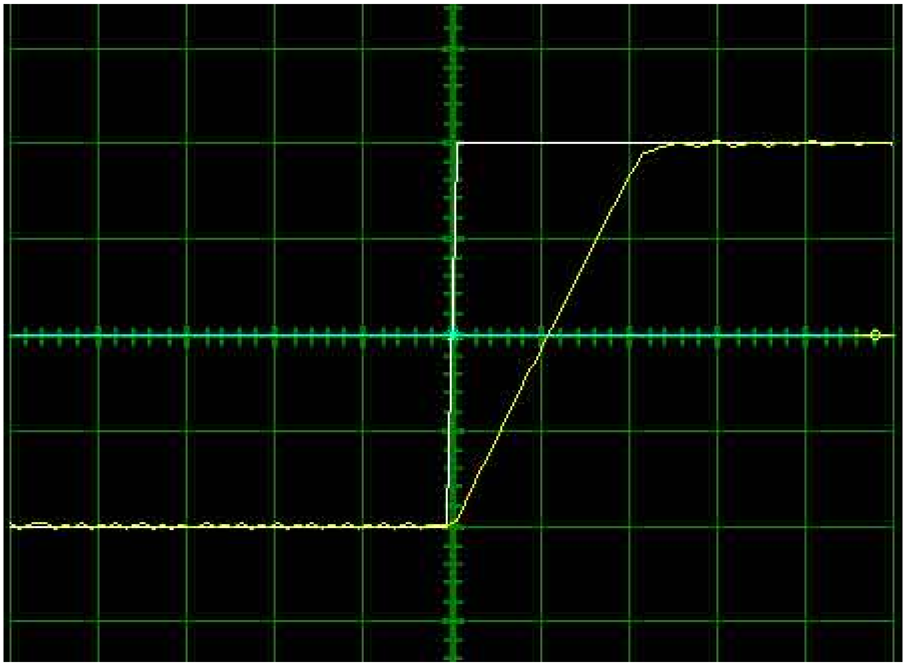
1. On the menu bar, select Tools --> Oscilloscope (or click the oscilloscope icon on the toolbar  ) to open the digital oscilloscope. Set up the scope view as follows.
2. Assign the channel 1 signal to **Motor Velocity Target** and the channel 2 signal to **Motor Velocity Measured** (use the "Change" button if necessary).
3. Change the Trigger Source to Motor Velocity Target with the Level set to zero.
4. Ensure Trigger Mode is Normal.
5. Change Time/Div to 10-20msec.

### Step 4: Tuning

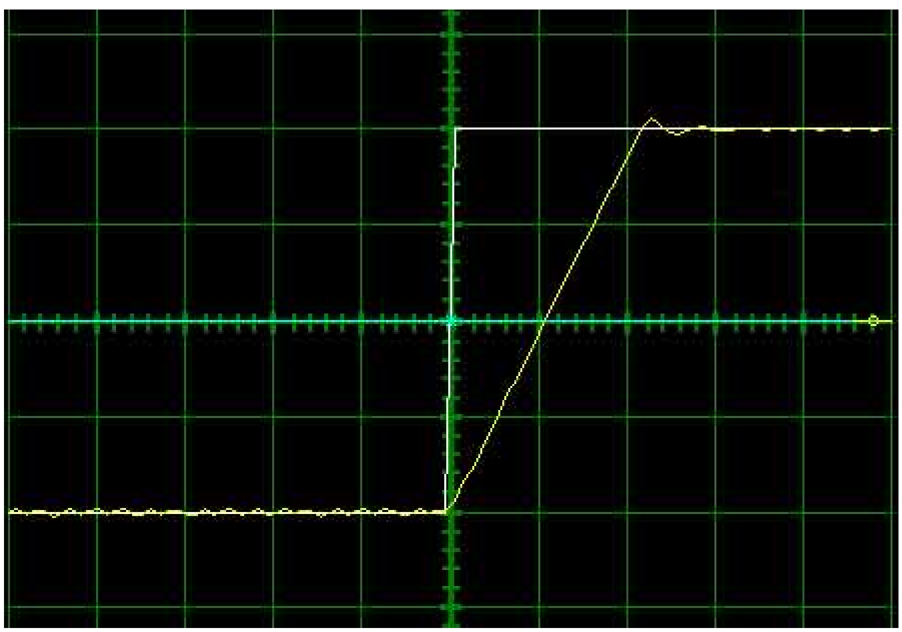
Position the Scope, Waveform Generator, and Velocity Loop windows such that a majority of all the windows are visible as shown. The best method is to place the oscilloscope in the lower left corner, while placing the current loop and Waveform Generator windows in the upper and lower right corners as shown below.




- Enable the drive by clicking the Enable/Disable Drive icon 
- The feedback filter cutoff frequency is used to dampen oscillations and noise in the velocity measurements. During the next steps, if the motor exhibits excess noise, bring the feedback cutoff frequency down to about 1000Hz or less. It is usually ok to start with this value also.
- Proper Velocity loop tuning starts with zero integral gain while increasing the proportional gain until a 'knee' is formed (with no overshoot) in the Velocity Measured trace as shown below. There may or may not be an error between the Target and Measured traces, the key is to have a smooth knee shape.



- At this point the Proportional gain is left alone and the Integral gain is increased slowly until the 'knee' begins to deform as shown below. It is ok if the waveform does not start to distort until the integral gain is very high. When the distortion occurs, back off the Integral gain until the knee becomes smooth again.



- Most systems will be tuned properly at this point. If your system is has unusual characteristics, it may be necessary to adjust the derivative gain. If you cannot achieve a desired velocity loop performance at this point, contact the AMC technical support group at http://www.a-m-c.com .

- Select the 'Not Connected' option in the waveform generator. If the motor starts to make audible vibrations, increase the Low Speed Gain until the vibration and noise stops.
- Disable the drive by clicking the Enable/Disable Drive icon .
- On the Menu Bar, select Communication --> Store (or click the Store Settings icon ), then OK to store parameters to the drive nonvolatile memory.

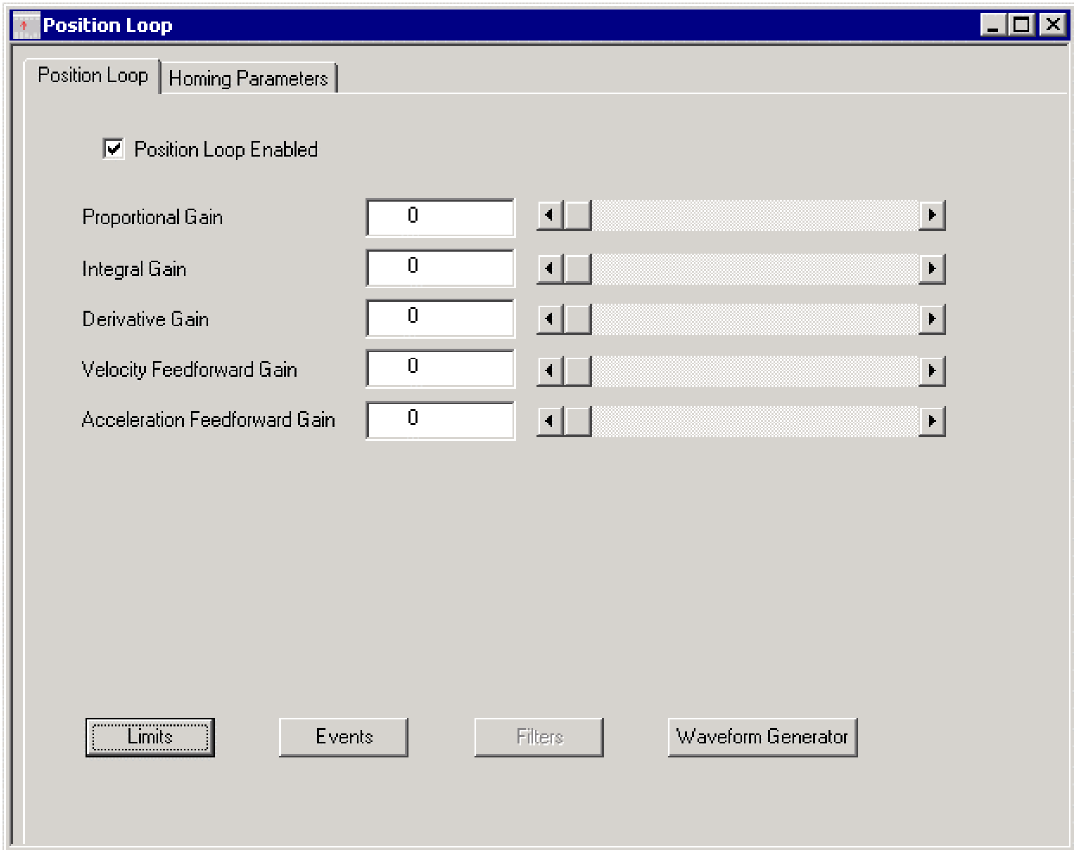
## *Position Loop Tuning*

Position loop tuning is dependant on the mechanical load, and therefore will change with any mechanical system changes. Position loop tuning should be performed with the motor installed in the system. The position loop can be closed around velocity or torque mode (depending on whether the velocity is enabled or disabled). If it is closed around velocity mode, the position loop algorithm output becomes the new velocity set point. If it is closed around torque mode, the position loop algorithm output becomes the new torque set point. There are some important differences in the tuning process and application of these two approaches:

**Position around Velocity:** This mode is most common in "contouring" application, where a position trajectory must be tracked very closely. The velocity loop provides additional "stiffness", and keeps the dynamic position errors minimal, since the system now reacts to not just position errors, but also velocity errors (which can be interpreted as position error *changes*). It is important to start with a stable yet responsive velocity loop. Typically, it is sufficient to just use the position loop proportional gain. Feedforward gain can be added to improve tracking performance (i.e. minimize the difference between commanded and actual position). It is best to use a small step command as a reference signal during tuning.

**Position around Torque:** This mode is most common in point-to-point applications, where actual motion between start and end point is not very critical. In this case, velocity loop tuning can be avoided. This can be advantageous if the velocity feedback is poor (e.g. low resolution encoder, poor encoder quadrature...). In this case, the tuning process requires that the position loop proportional and derivative gain are increased simultaneously, unless the system has sufficient friction, in which case no derivative gain is necessary. Once a stable response is achieved, integral gain can be added to improve stiffness. It is best to use a triangular waveform or a step command with the profiler enabled as a reference signal during tuning.

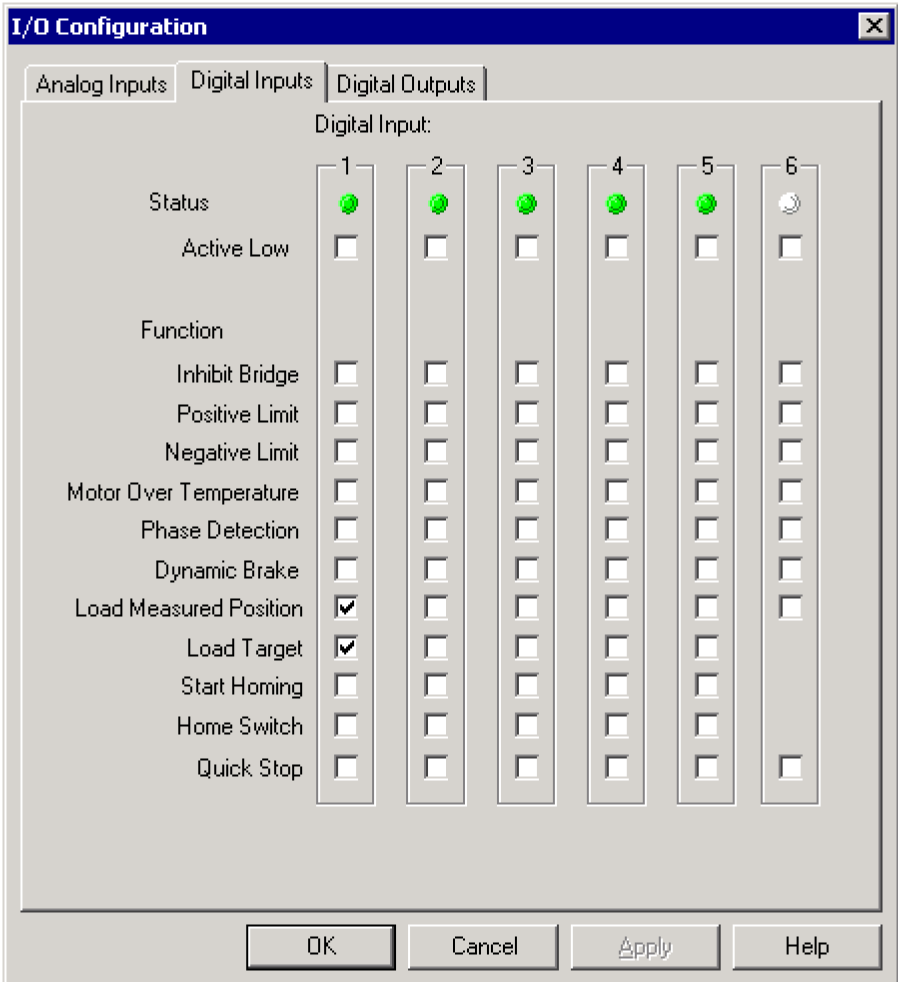
## Step 1: Position Loop Window Set  Up




1. Verify the drive is disabled
2. From the Main Block Diagram, open the *Position Loop* window.
3. Set the *Proportional*, *Integral*, Derivative, *Velocity Feedforward*, and *Acceleration Feedforward* gains to zero.
4. Select the check box for *Position Loop Enabled.*

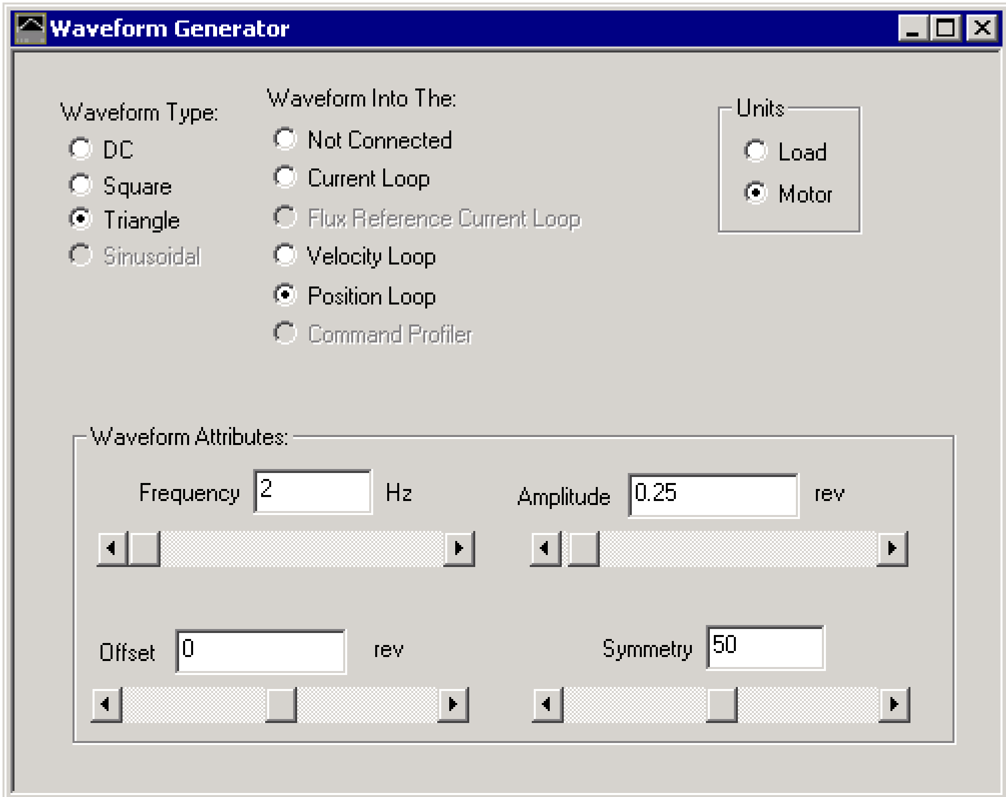
## Step 2: Zero the Measured and Target Position

It is necessary to zero the target and measured position so that they are equal to each other, and the motor does not run away when the bridge is enabled. Before continuing with this step, click on the *Config* block in the Main Block Diagram and select the position limits tab. Verify the value of Measured Position is set to zero.




1. From the Main Block Diagram, click *I/O Configuration* and select the Digital *Inputs* tab.
2. Set the Measured Position to zero by checking *Load Measured Position* under and assigned input. Set the Target Position to zero by checking *Load Target* under an assigned input. Click the apply button.
3. Clear the check boxes checked in *2.* and once again click Apply.
4. Click OK to close the *I/O Configuration* window.

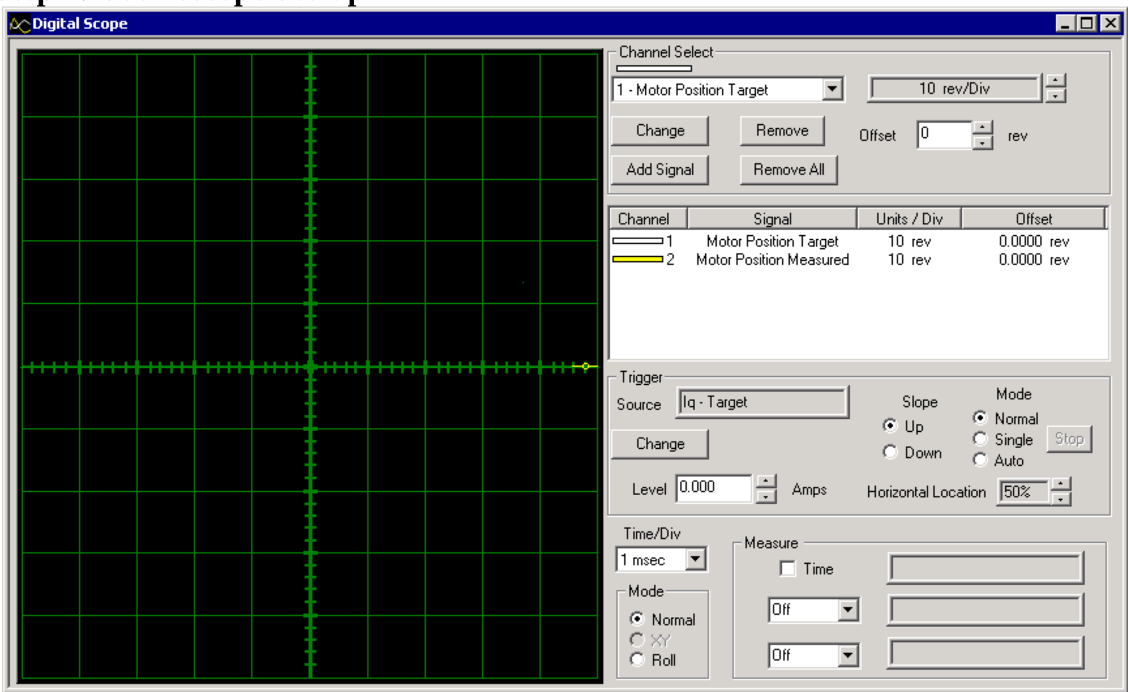
### Step 3: Waveform Generator Set Up




In the Position Loop window, click the *Waveform Generator* button (or select Tools --> Waveform Generator on the menu bar) to open the Waveform Generator screen. Set up the Waveform Generator as follows.

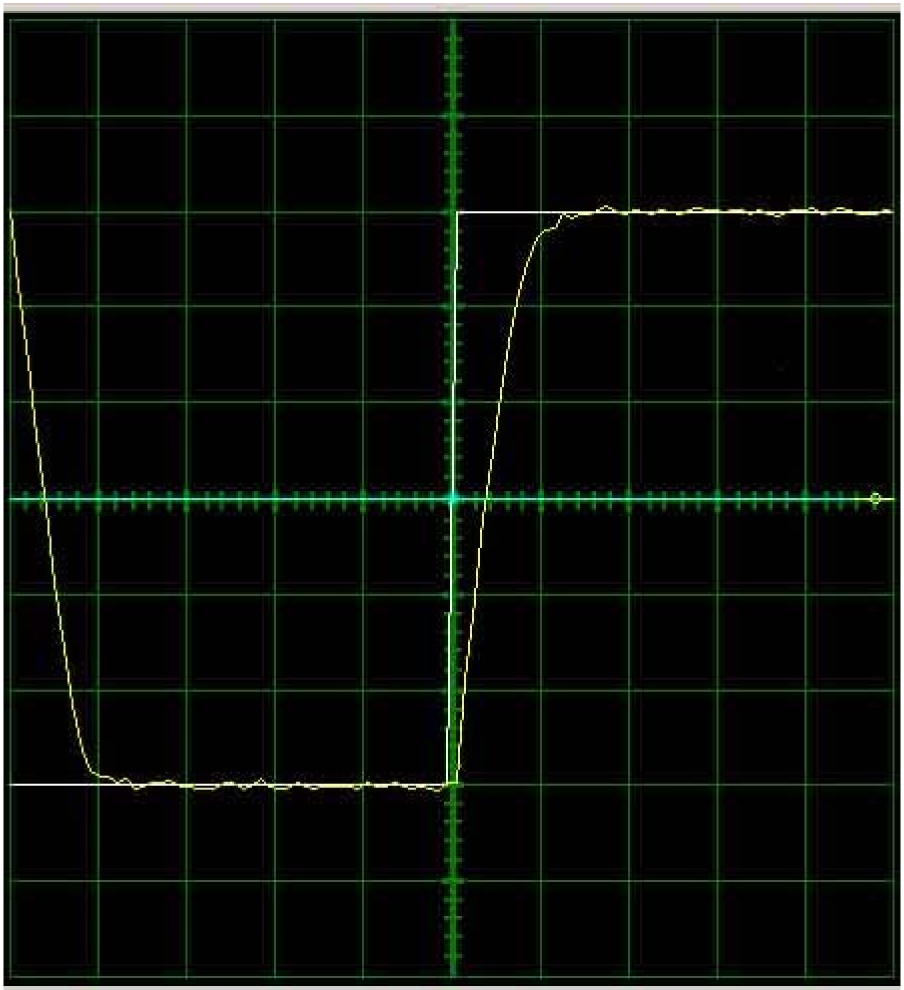
1. Select the *Square* Waveform Type.
2. Set *Frequency* to around 2-3 Hz. The Frequency should be slow enough to allow the motor to settle in position.
3. Ensure *Offset* is zero.
4. Ensure *Symmetry* is 50%.
5. Select *Waveform Into The Position Loop*.
6. Set the waveform amplitude between 1//8 and 1/2 revolution for a rotary motor.

## Step 4: Oscilloscope Set Up




1. On the menu bar, select Tools --> Oscilloscope (or click the oscilloscope icon on the toolbar ) to open the digital oscilloscope. Set up the scope view as follows.
2. Use the drop down menu to change the channel 1 signal to Motor Position Target.
3. Use the drop down menu to change the channel 2 signal to Motor Position Measured.
4. Change the Trigger Source to Motor Position Target with the Level set to zero.
5. Ensure Trigger Mode is Normal.
6. Change Time/Div to 20-50 msec.

**Step 5: Tuning**



1. Position the Scope, Waveform Generator, and Current Loop windows such that a majority of all the windows is visible.
2. Enable the drive by clicking the Enable/Disable Drive icon
3. Use the Proportional Gain, Integral Gain, and Derivative Gain sliders or arrow buttons to adjust the Motor Position Measured waveform on the oscilloscope and match the Motor Position Target as closely as possible without excessive overshoot. It is not necessary to adjust the Velocity or Acceleration Feedforward Gains.
4. Readjust the Gains as Necessary.
5. Disable the drive by clicking the Enable/Disable Drive icon .
6. When position loop gain adjustments are complete, click Not Connected on the Waveform Generator to remove the command signal from the drive.
7. On the Menu Bar, select Communication --> Store (or click the Store Settings icon ), then OK to store parameters to the drive nonvolatile memory.

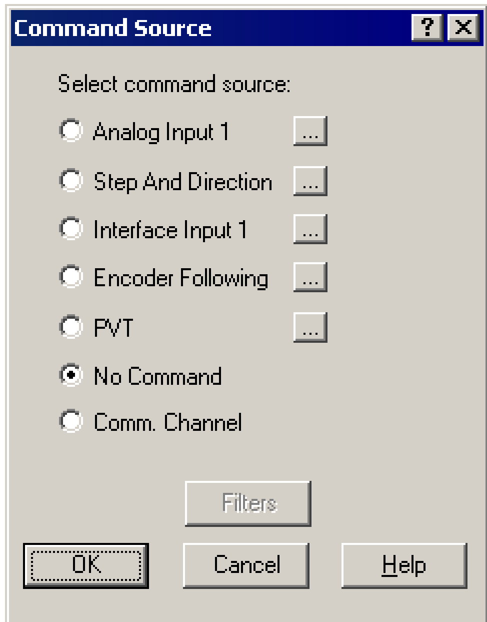
# Command Input and Scaling

Once the drive's commutation parameters, limits, and tuning values are configured, it is ready to have I/O configured for machine control. General I/O is provided for use with limit switches, temperature sensors, brakes, and other safety devices. See the hardware manual for your specific drive to determine how to interface with the drive's I/O. The last step to commissioning the drive is setting and scaling the Command Source. Use the following links to perform final I/O and Command source configuration.

1. Command Source
2. I/O Configuration

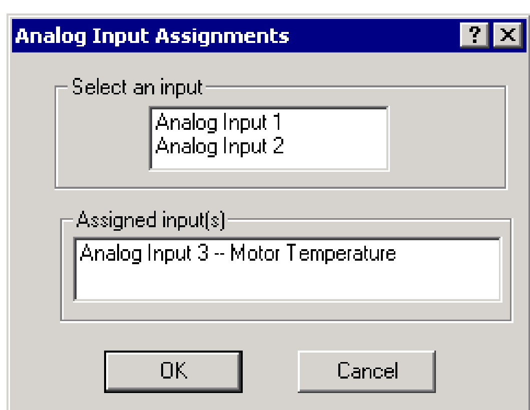
### *Command Source*

The Command Source window can be opened by clicking on the command source block in the main block diagram. It allows selection and configuration of the command source. The following command sources are available (depending on operating mode):



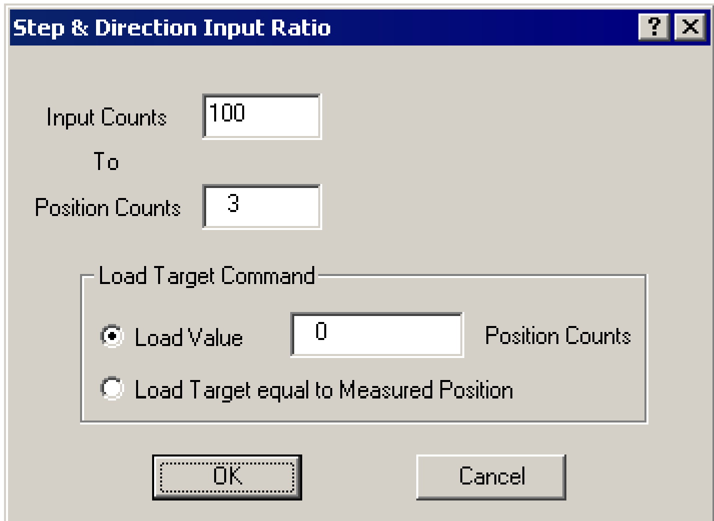

- **Analog Input**

Selects an analog input as the command source for the drive. Configuration of this input can be done in the I/O Configuration window. The  button displays analog input assignments as shown below. All analog inputs are shown. If more than one is available, you may select it from the *Select an input* box. You may not select an input shown in the *Assigned input(s)* box because it is assigned to another task.



- **Step And Direction**

  Selects the step and direction inputs (see hardware manual or data sheet) to control the motor in a simulated stepper motor configuration. Click on the button to show the Step & Direction Input Ratio window as described below.




  *Input Counts* are the number of input pulses desired to move the motor by a given number of counts. *Position Counts* is the number of counts desired to move for the given input counts. If using an encoder, *Position Counts* represents the number of encoder counts. If using a resolver drive, *Position Counts* represents the number of resolver counts as determined by the specified resolver resolution. The number entered in either field must be between 1 and 65535.

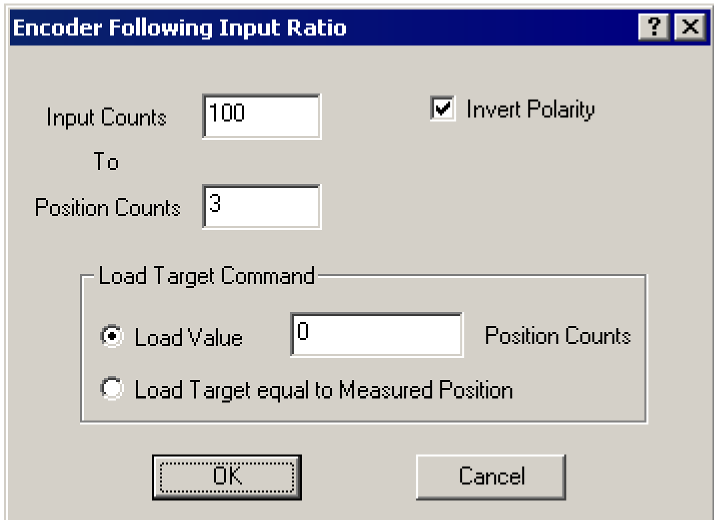
  The *Load Target Command* specifies what occurs when you activate a *Load Target* command via a digital input. You may choose the drive to load a specified count into the position target, or you may choose the drive to set the target position equal to the currently measured position. Be aware that the first option may cause the motor to jump to the specified target position when activated.

- **Interface Input**

  Selects the communication interface as the command source for the drive. This means that a new command value is set via the interface. The button displays the commanded input assignments and allows you to select a specific commanded input.

- **Encoder Following**

  Selects the secondary encoder input (see hardware manual or data sheet) to drive the motor in a master/slave configuration. Click on the ... button to bring up the window shown below.



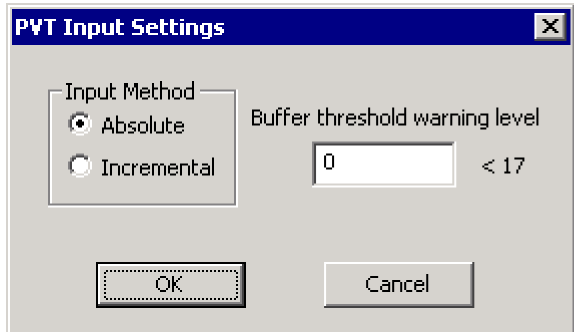

  *Input Counts* are the number of quadrature input pulses desired to move the motor by a given number of counts. *Position Counts* is the number of counts desired to move for the given input counts. If using an encoder for primary feedback, *Position Counts* represents the number of encoder counts to move. If using a resolver for primary feedback, *Position Counts* represents the number of resolver counts as determined by the specified resolver resolution.

  The *Invert Polarity* checkbox changes the resulting motor direction for a given input command.

  The *Load Target Command* specifies what occurs when you activate a *Load Target* command via a digital input. You may choose the drive to load a specified count into the position target, or you may choose the drive to set the target position equal to the currently measured position. Be aware that the first option may cause the motor to jump to the new target position when activated.

- **PVT**

  Selects PVT as the control mode. Click the ... button to bring up the window shown below.




The PVT input method widow allows you to select between Absolute and incremental PVT points. It also allows you to define the buffer level at which a buffer threshold warning will occur.

- **No Command**

This assigns no command source to the drive. Typically, *No Command* will be automatically assigned when major control loop changes are performed. This is a protection feature to minimize sudden motor movement.

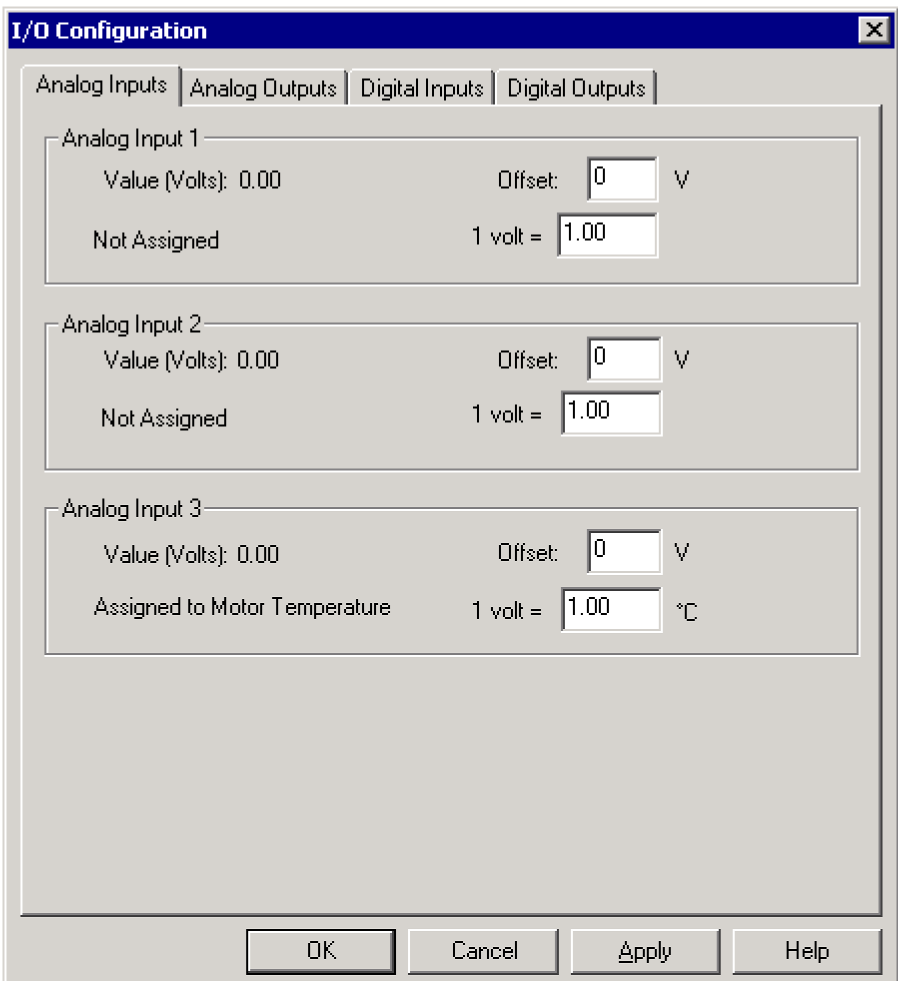
- **Comm. Channel**

The command will automatically be assigned when the drive is being controlled by an outside source. This capability is currently only available with our CANopen products.

### *I/O Configuration*

The I/O Configuration window allows configuration and diagnostics of all digital and analog programmable inputs and outputs. This window can be accessed by clicking on the I/O icon on the main screen.

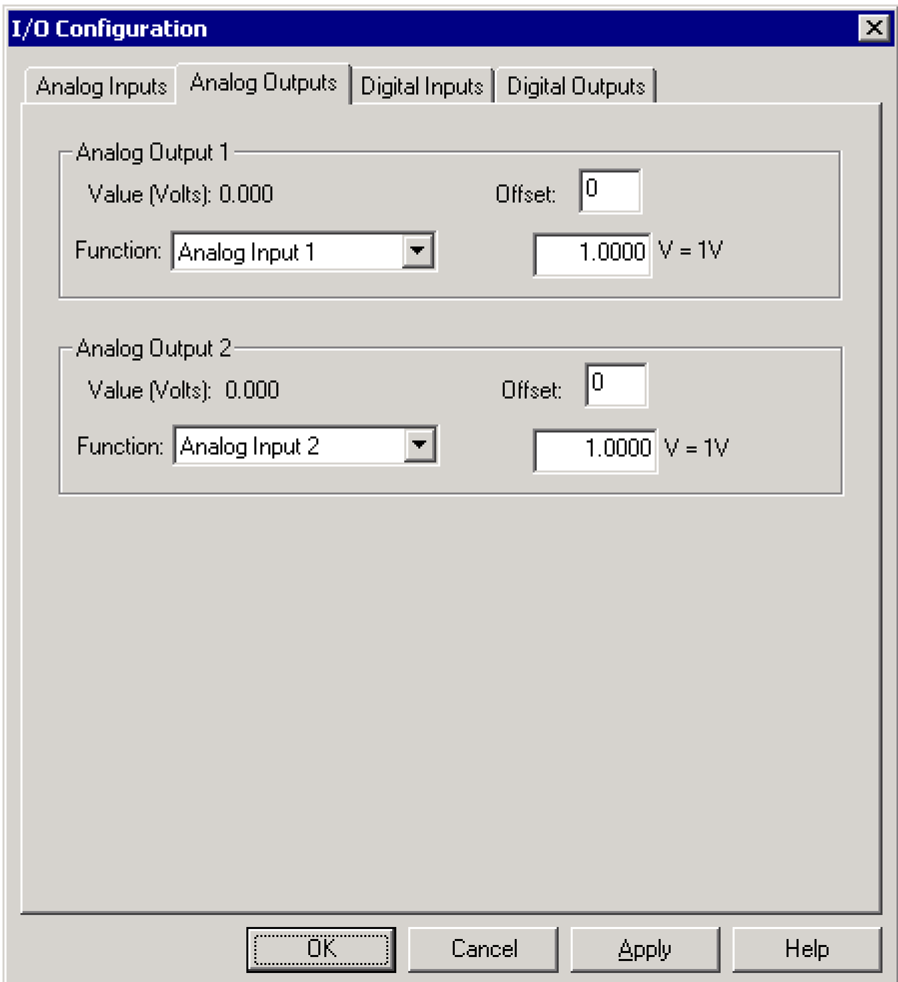
**Analog Inputs:**




- Each programmable analog input can be assigned a certain drive function. Assignment of these functions can be made in the Command Source or Feedback window. Each input can also be scaled, according to the selected function, to provide an optimal range. Entering the numerical value of the chosen function for a 1V input signal performs the scaling. An offset (in Volts) can also be defined.

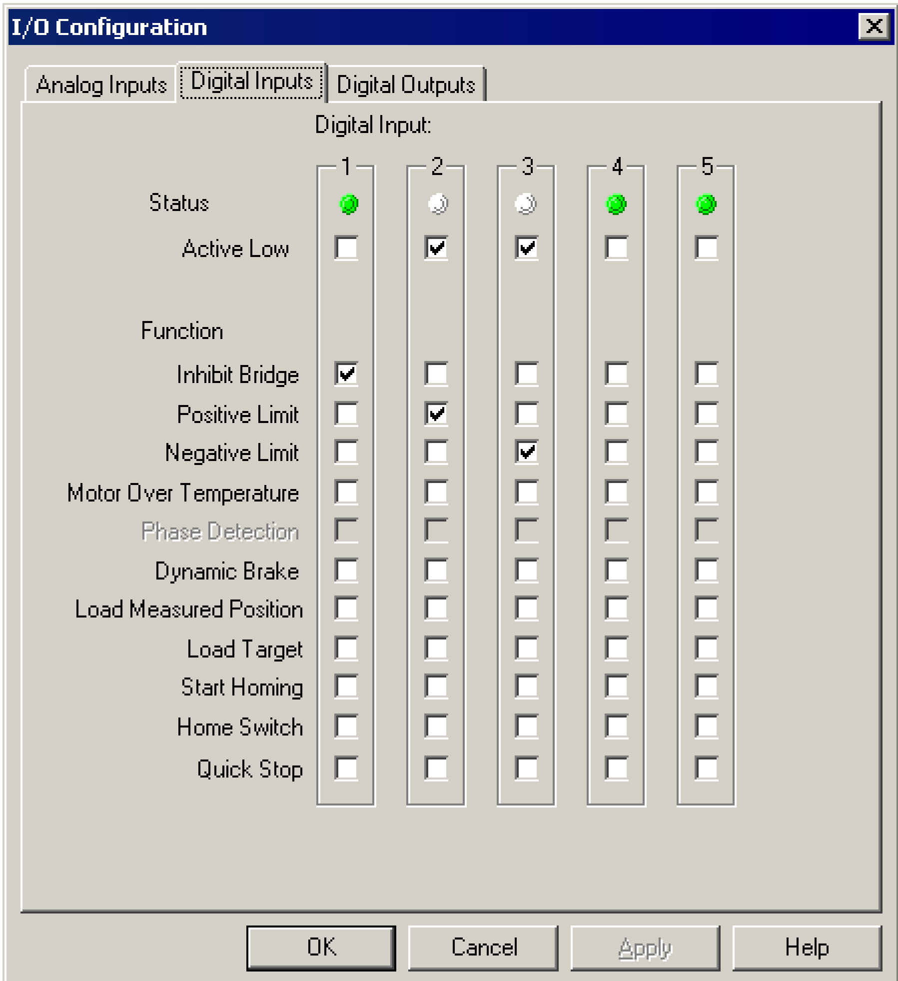
- Note: selections become effective, after clicking the Apply or OK button.
- Check the drive data sheet to find the number of available analog inputs.

**Analog Outputs:**




- Each programmable analog output can be assigned to a certain drive variable.
- Each output can also be scaled, according to the selected variable, to provide an optimal range. Entering the numerical value of the chosen variable for a 1V output signal performs the scaling.
- An offset (in Volts) can also be defined.
- Note: selections become effective, after clicking the Apply or OK button.
- Check the drive data sheet to find the number of available analog outputs.
- A list of available outputs signals and their definitions can be found in the Signal Definitions page.

**Digital Inputs:**

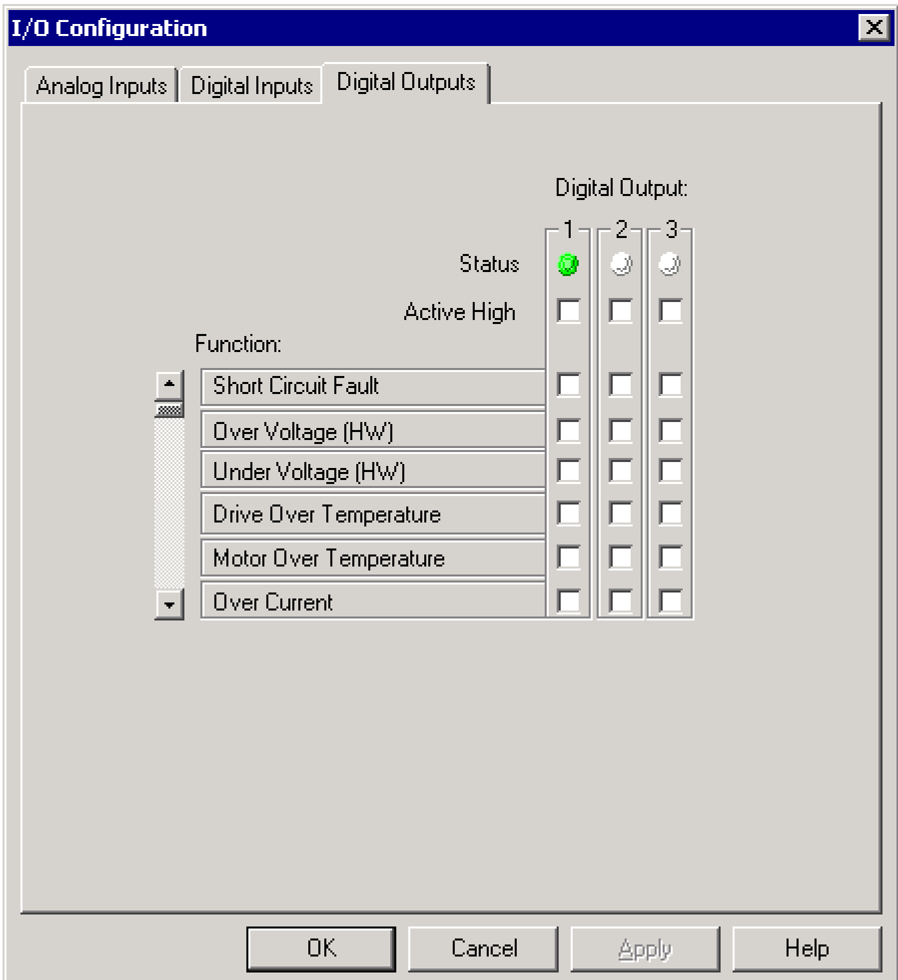



- The present status of each input is displayed (gray= Not Active, green= Active). The Active Low checkmark determines the input polarity. Active low means the input must be pulled-down for the input to be considered ON.
- Each input can be assigned to one or more functions via the checkmark matrix. If more then one function is assigned to a single input, the following priority rules apply (from highest to lowest):

  Inhibit
  Dynamic brake
  Positive or negative inhibit
  Phase Detection
  The Motor Over Temperature function depends on the selected function in the Drive Control window.

- Note: selections become effective, <u>after</u> clicking the Apply or OK button.

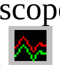
**Digital Outputs:**



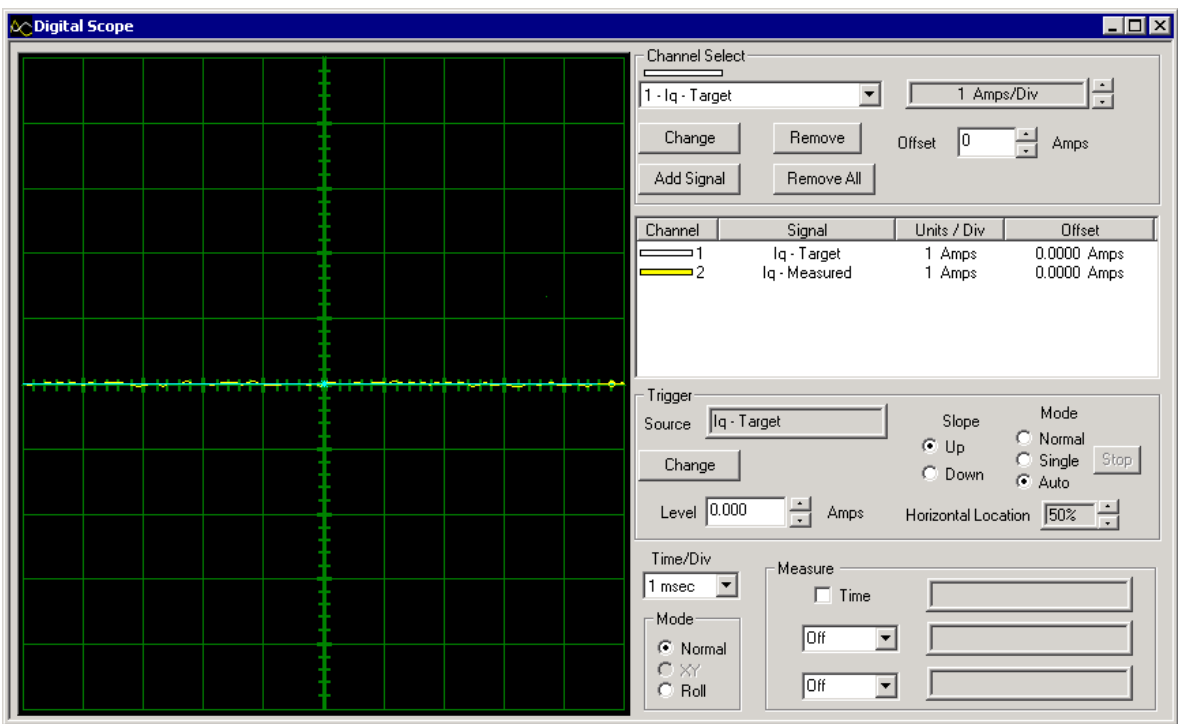

- The present status of each output is displayed (gray= Not Active, green=Active). The Active High checkmark determines the output polarity. Active High means the output is pulled-down if the output is considered OFF. Each output can be assigned one or more functions via the checkmark matrix. If more then one function is assigned to a single output, the functions are OR-ed, which means that if one of the functions is true, the output will be turned ON.
- Note: selections become effective, <u>after</u> clicking the Apply or OK button.

# Appendix

### *Digital Scope*

The digital oscilloscope may be opened by going to Tools > Oscilloscope on the menu bar, or by clicking  on the toolbar. The oscilloscope provides real-time feedback during tuning and setup. This multi-channel digital scope behaves similarly to a traditional oscilloscope but provides access to internal drive signals. You may have a maximum of eight channels shown at any one time depending on the bandwidth used for each channel. The units used in the vertical division setting depend on the selected signal. Standard prefixes such as u (micro-), m (milli-), k (kilo-), M (mega-), etc. are used for larger scaling factors. The bridge does not need to be enabled to use the scope. All that is required is that the drive be powered up and connected. An explanation of how to use the scope is described below.

**Digital Scope Window**

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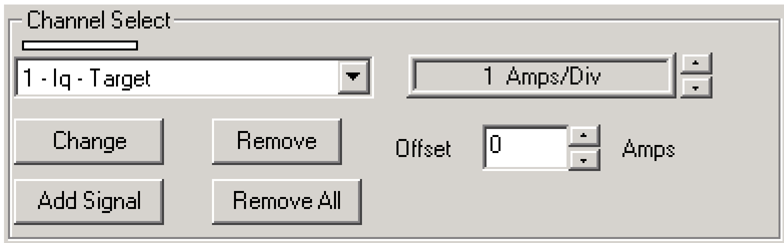
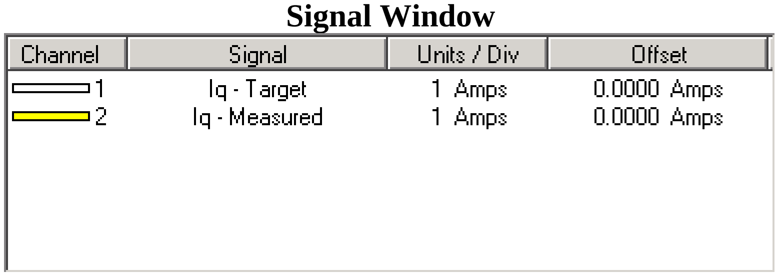
The digital scope is a powerful tool that comes in handy during tuning and diagnostics. You can select from more than forty different signals to monitor while testing or troubleshooting your machine. Detailed descriptions of scope components are described below.

### Channel Select




- **Channel select drop down menu:** Allows you to select which channel you wish to display.
- **Change:** This opens a new window so you can use the selected channel to display a signal of your choice.
- **Add Signal:** Adds a new channel to the scope (if available) and allows you to select a corresponding signal of your choice. This button will be disabled (grey) if all oscilloscope channels are used.
- **Remove:** Removes the selected channel from the scope.
- **Remove All:** Removes all channels, resulting in no signals displayed.
- **Signal Scaling:** Allows you to adjust the scale in units per division. The type of units used changes depending on the signal chosen. The signal to be scaled corresponds to the channel selected in the channel select drop down menu.
- **Offset:** Adjusts the offset of the signal shown in the digital scope display. The offset corresponds to the channel selected in the channel select drop down menu.
- A list of available channels and their definitions can be found in the Signal Definitions page.

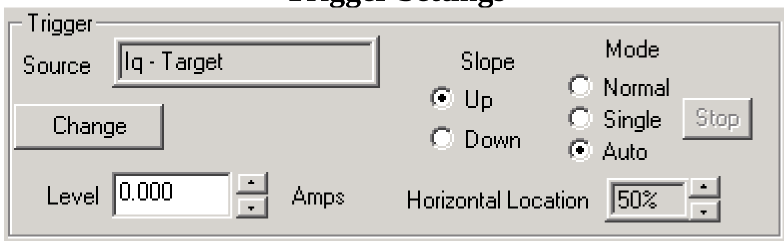
### Signal Window




- **Channel:** Shows the color associated with the channel as seen in the digital scope display
- **Signal:** Shows the signal associated with the color and channel.
- **Units/Div:** Shows the units per division for the corresponding signal as seen in the digital scope display.

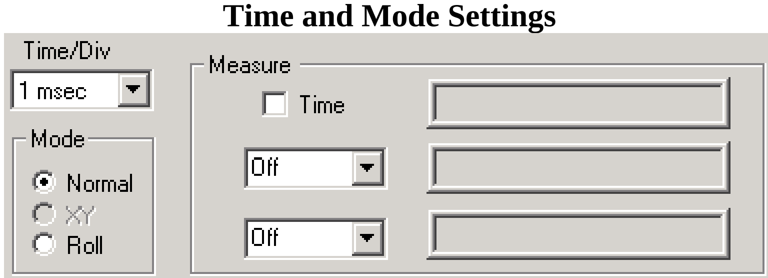
- **Offset:** Shows the offset associated with the signal as seen in the digital scope display

**Trigger Settings**




- **Source:** Displays the currently selected signal to be used as a trigger.
- **Change:** Allows you to change the trigger source.
- **Level:** Allows you to select the level at which you want the scope to trigger.
- **Slope:** Sets the trigger slope to positive slope or negative slope.
- **Mode:** Sets the trigger mode to one of the following: **Normal Mode:** The scope triggers according to the settings specified. **Single:** The scope triggers once, according to the settings specified, after Run/Stop button is selected. **Auto:** The scope triggers automatically, ignoring the settings specified.
- **Horizontal Location:** Allows you to adjust the horizontal (time-based) level at which the scope triggers.

**Time and Mode Settings**



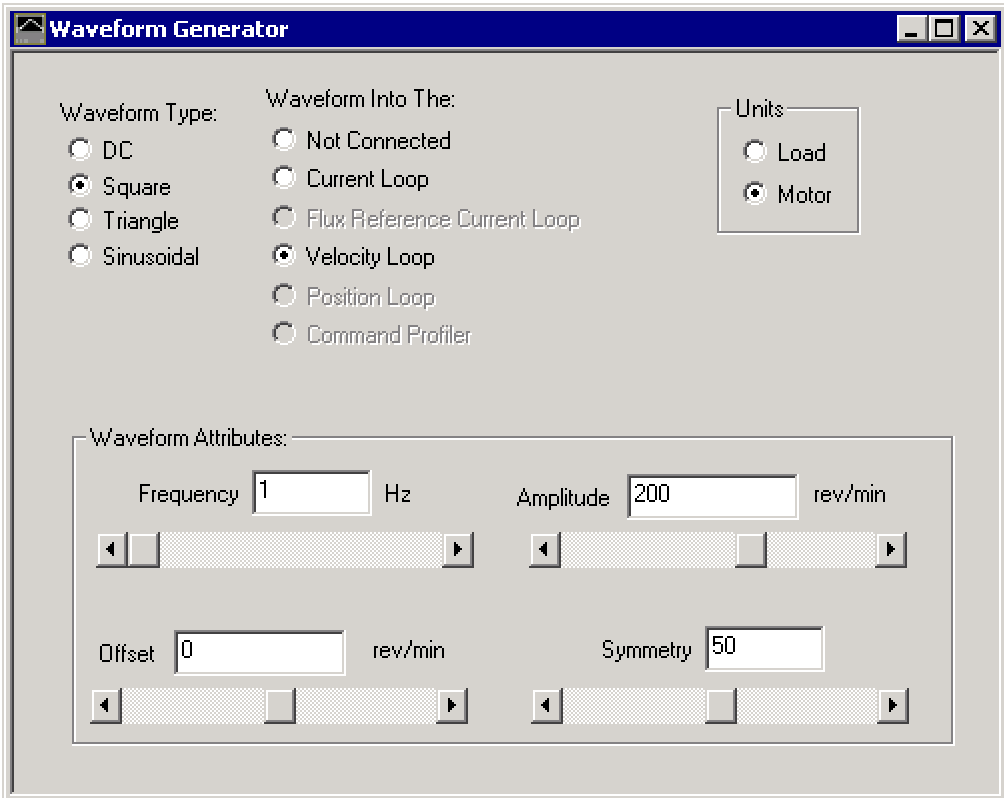

- **Time/Div:** Sets the horizontal scaling as seen on the scope in units of time per division
- **Mode:** Sets the mode in which the scope captures data. **Normal** mode refreshes the screen in intervals dependant on the time per division selected. A longer time period selected will take longer to update the scope. **Roll** mode captures data and refreshes the screen in a continuous roll. Note: you will be limited to 200 msec/Div minimum while in roll mode.
- **Measure:**

1. **Time:** This allows you measure time differences between any two point on the scope display. Click the **Time** checkbox to display two vertical lines on the scope plot. The difference in time between the two lines is displayed in the box to the right of the check box. Left click to drag each line or right click to drag both.

2. **Signal Level:** Select a channel for measurement from one of the two dropdown boxes. You may use either of the two dropdown menus to select a channel. The vertical difference between the horizontal lines is displayed next to the channel selection dropdown; the selected channels units apply. Left click to drag each line or right click to drag both.

### *Waveform Generator*

The Waveform Generator is used to generate an internal signal during drive tuning and other procedures. With this waveform generator, the need for external signal sources during tuning is eliminated. The *Units* select option allows you to choose between using load units or motor units as defined in the User Units window. To open the waveform generator, go to Tools > Waveform generator on the menu bar.



| | |
|---|---|
| **Waveform Type:** | Select a DC (constant), square wave, triangle wave, or sinusoidal waveform. The sinusoidal waveform option is not available when waveform generator is connected to the position loop |
| **Waveform Into The:** | Select the destination for the waveform signal. Not Connected means the waveform signal will not be used. *Command Profiler* means the command signal will be limited as defined in the<br>Command Profiler Window. |
| **Units:** | Selects whether the amplitude and offset will be defined in load units or motor units. These units are configured in the User Units during the Drive Parameter Configuration process. |
| **Frequency:** | Select the frequency of the waveform signal. This becomes<br>inactive when "DC" is selected for the waveform type. |
| **Amplitude:** | Corresponds to the amplitude of the waveform signal (equivalent to half of the peak-to-peak value). Disabled in case a DC waveform is selected. |
| **Offset:** | Adds an offset to the selected waveform. If a DC waveform is selected, the offset corresponds to the DC signal amplitude. |
| **Symmetry** | Corresponds to the duty cycle or symmetry of the waveform signal. This becomes inactive when DC is selected for the waveform type. |

## *Command Profiler*

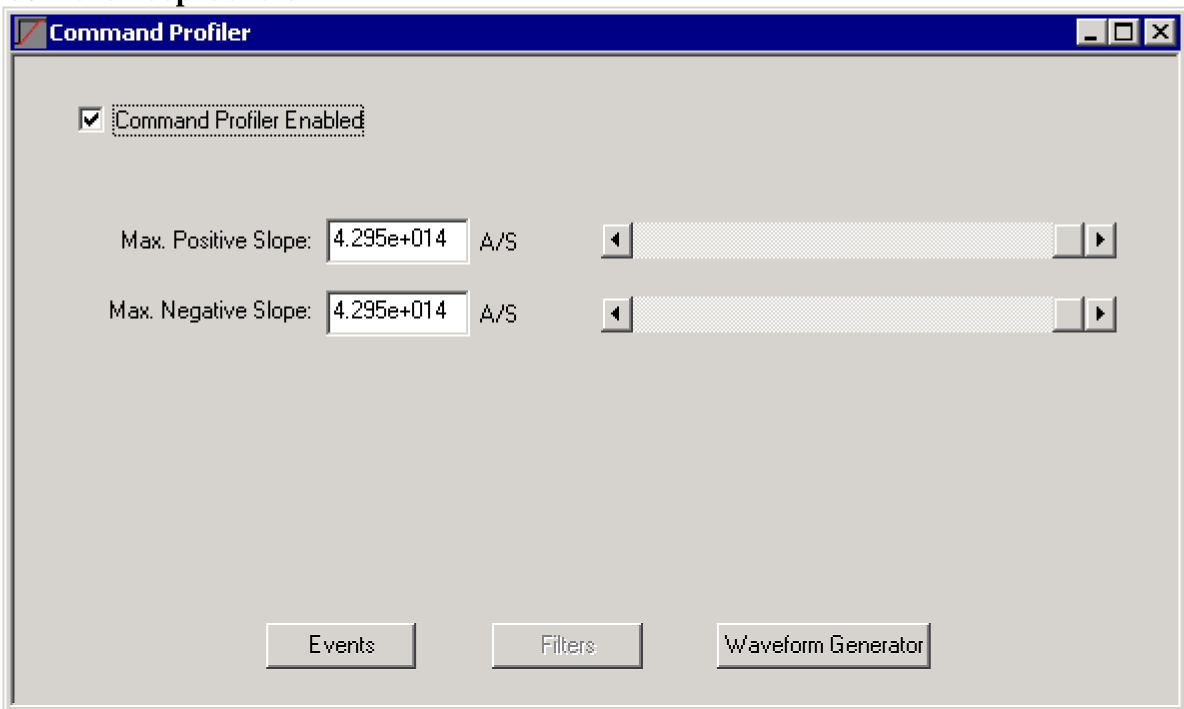
The Command profiler allows you to limit the change in input command signal as seen by the drive. The resulting effect is dependant on the operating mode. This is a command smoother, not a drive limiter. In other words, it will change how the command is seen by the drive, but if an event occurs which is not affected by the command, the drive will react according to drive limits. For changing drive limits, see Drive Configuration.

The Command Profiler window can be opened by clicking on its icon in the main block diagram.

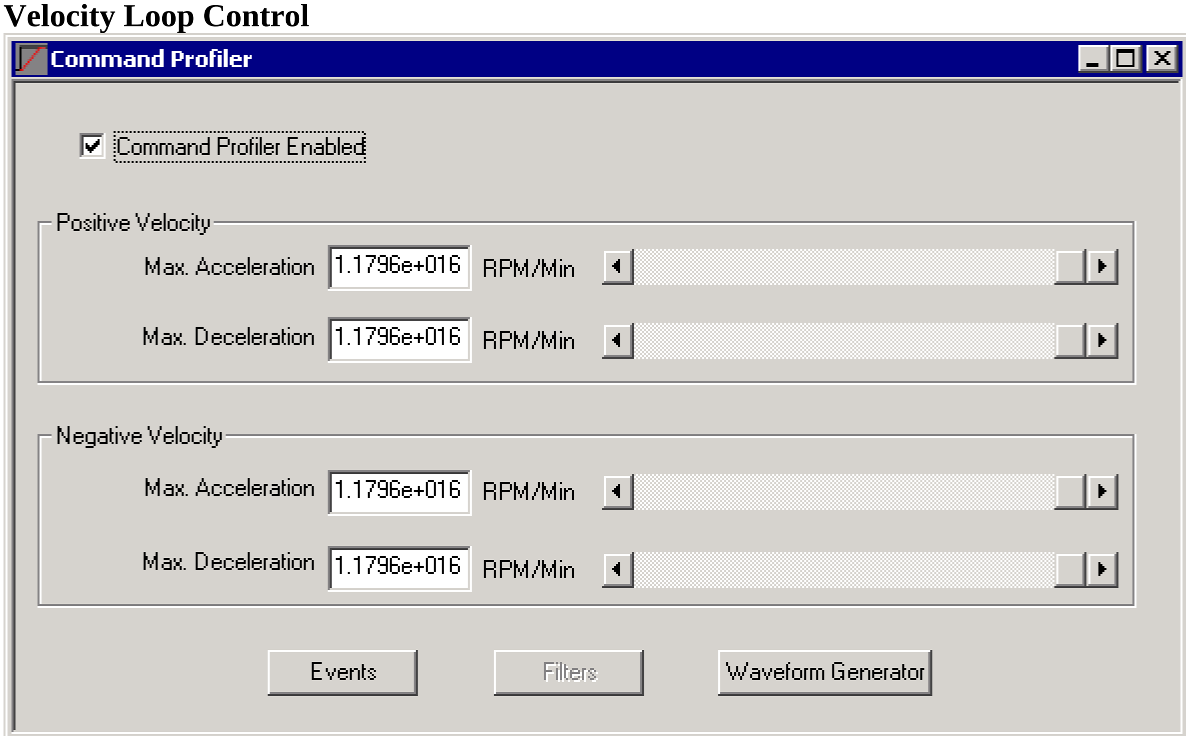
**Current Loop Control**
Limits the jerk, or change in commanded torque.
**Velocity Loop Control**
Limits the acceleration, or change in commanded velocity.
**Position Loop Control**
Limits the velocity, or change in commanded position.

The Command Profiler window changes depending on the mode of operation you are using. See below for the three possible windows.

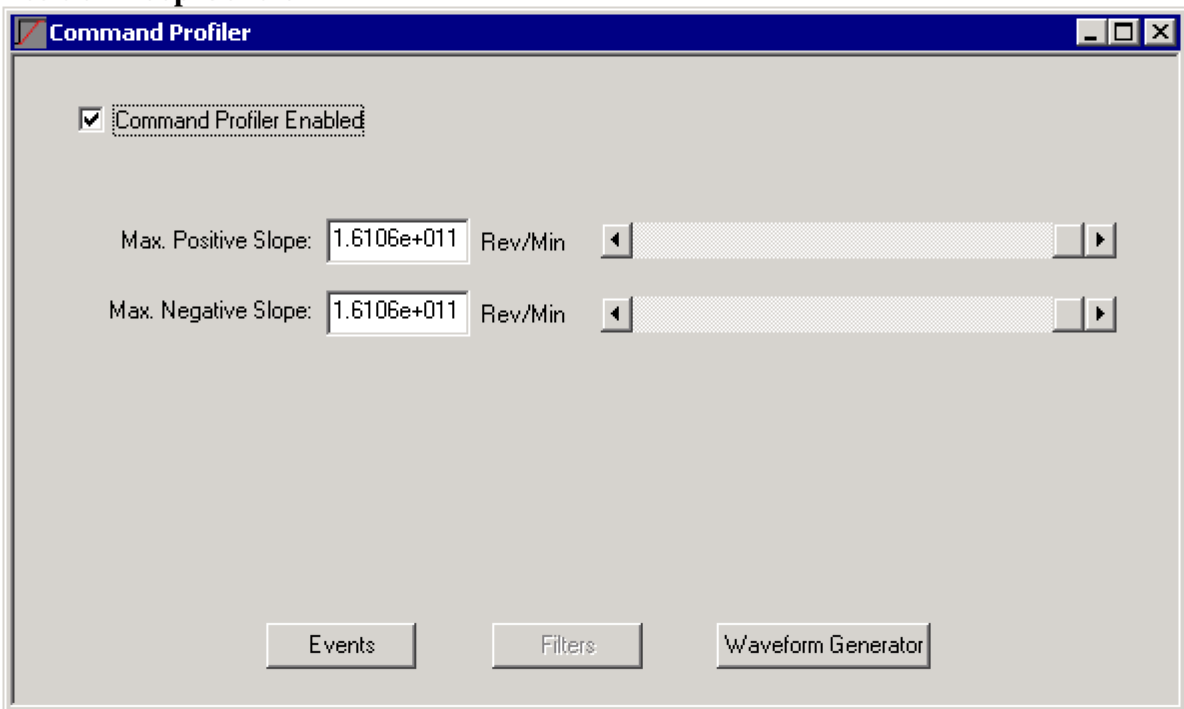
## Current Loop Control




## Velocity Loop Control



## Position Loop Control



## *Signal Definitions*

The following tables show all of the signals that can be measured using the Oscilloscope and Multimeter. These signals may also be used as analog outputs in compatible drives.

**Note** : Depending on the drive type, motor type, and motor settings, some of the signals may not be available.

### Current Measurements

| Value | Definition |
|---|---|
| Iq - Target | This is the commanded current ignoring current limit settings. |
| Iq - Demand | The commanded current, after current limits have been applied. This value is zero when the drive is inhibited. |
| Iq - Measured | The actual measured current being delivered to the motor. Ideally, this value should be as close as possible to the demand current. |
| Id - Target | This represents the flux producing stator current in an AC induction motor. Id should equal zero when using a permanent magnet motor. |
| Id - Demand | This represents the flux producing stator current in an AC induction motor. Id should equal zero when using a permanent magnet motor. |
| Current Phase A | The measured current in motor phase A. The sum of all three phases should add up to zero. |
| Current Phase B | The measured current in motor phase B. The sum of all three phases should add up to zero. |
| Flux Ref. Current Target | The commanded flux reference current ignoring limits. The flux reference current is the current induced in the rotor of an AC induction motor. |
| Flux Ref. Current Demand | The commanded flux reference current, after limits have been applied. The flux reference current is the current induced in the rotor of an AC induction motor. |

| | |
|---|---|
| Flux Ref. Current Measured | The measured flux reference current. The flux reference current  is the current induced in the rotor of an AC induction motor. |
| Flux Ref. Current Error | The difference between the flux reference current target and the flux reference current measured. |

## Velocity Measurements

| Value | Definition |
|---|---|
| Motor Velocity Target | This is the commanded velocity ignoring velocity limit settings. |
| Motor Velocity Demand | The commanded velocity, after velocity limits have been applied. This value is zero when the drive is inhibited. |
| Velocity Feedback | The velocity as measured by the velocity feedback device (before filtering) |
| Motor Velocity Measured | The velocity as measured by the velocity feedback device (after filtering) |
| Velocity Error | The difference between the motor's target velocity and measured velocity. |
| Load Velocity Measured | This is equal to the velocity measured, but displayed in load units. |

## Position Measurements

| Value | Definition |
|---|---|
| Motor Position Measured | The position as measured by the position feedback device. |
| Motor Position Target | This is the commanded position ignoring position limit settings. |
| Motor Position Demand | The commanded position, after position limits have been applied. |
| Position Error | The differenece between the motor's target position and measured position. |
| Load Position Measured | This is equal to the position measured, but displayed in load units. |
| Auxilliary Input | The position value measured from the drives auxilliary |

| | |
|---|---|
| | inputs. |

## Commutation

| Value | Definition |
|---|---|
| Sync Error | The error between the actual number of encoder counts compared to the expected number of encoder counts as entered in the Motor page. Values will vary depending on Hall or Index synchronization. |
| Hall State | The decimal equivalent of the binary combination of the three hall states where Hall A is bit 1 and Hall C is bit 3. (5V = 1, 0V = 0) |
| Phase Angle | The present number of degrees of the rotor inside one electrical cycle. Also may be called Electrical Angle. |
| Sync. Capture | The encoder count captured at the Synchronization edge. This will vary depending on the Sync edge chosen from autocommutation (Hall or Index edge). |
| Stator Angle | The present number of degrees of the stator inside one electrical cycle. This value is equal to the phase angle plus the slip angle. |

## Voltage

| Value | Definition |
|---|---|
| Analog Output 1 | The present voltage applied to analog output 1. |
| Analog Output 2 | The present voltage applied to analog output 2. |
| DC Bus Voltage | The present voltage applied to the high voltage input of the drive. |
| Voltage Phase A | The voltage, with respect to DC bus ground, applied to motor phase A |
| Voltage Phase B | The voltage, with respect to DC bus ground, applied to motor phase B. |
| Voltage Phase C | The voltage, with respect to DC bus ground, applied to motor phase C. |
| Analog Input 1 | The voltage, with respect to signal ground, applied to analog input 1. |
| Analog Input 2 | The voltage, with respect to signal ground, applied to analog input 2. |

| | |
|---|---|
| Analog Input 3 | The voltage, with respect to signal ground, applied to analog input 3. |

## Command Profiler

| Value | Definition |
|---|---|
| Command Profiler Input | The commanded signal input to the Command Profiler. When the Command Profiler is enabled, all commands pass through it first for profiling. |

## Temperatures

| Value | Definition |
|---|---|
| Motor Temp. | The present temperature of the motor read and scaled from the appropriate analog inputs. |
| Drive Temperature | Depending on the specific drive, an analog temperature sensor may be present to report the actual drive temperature. |

## Torque

| Value | Definition |
|---|---|
| Load Torque Measured | The torque applied at the load. This value is calculated from measured current, as delivered to the motor from the drive, and other user supplied parameters in the Motor Data and User Units windows. |
| Motor Torque Measured | The torque applied by the motor. This value is calculated from measured current, as delivered to the motor from the drive, and other user supplied parameters in the Motor Data window. |

Drive

| Value | Definition |
|---|---|
| Drive Position | The drive position as measured by the primary feedback device. No position is measured when Hall sensors are used as the only primary feedback device. Always measured in units of counts. |
| Drive Velocity | The drive velocity as measured by the primary feedback device. No velocity is measured when Hall sensors are used as the only primary feedback device. Always measured in units of counts. |

Commanded Input Value

| Value | Definition |
|---|---|
| Commanded Input Eight | The decimal value read from interface input 8. |
| Commanded Input Seven | The decimal value read from interface input 7. |
| Commanded Input Six | The decimal value read from interface input 6. |
| Commanded Input Five | The decimal value read from interface input 5. |
| Commanded Input Four | The decimal value read from interface input 4. |
| Commanded Input Three | The decimal value read from interface input 3. |
| Commanded Input Two | The decimal value read from interface input 2. |
| Commanded Input One | The decimal value read from interface input 1. |

### *Drive Status*

The Drive Status window shows the drive status in three categories:

**Drive Protection Status:** these are internal drive faults and states

| Event | Description |
|---|---|
| Drive Reset | Indicates that the drive powered up in a disabled state. This occurs each time the drive is reset. |
| Drive Internal Error | Checksum error of the drive run-time firmware. |
| Short Circuit | Short circuit detected on the output power stage. |
| Current Overshoot | The actual output current exceeds the peak current capability of the power output stage. Typically caused by overshoot in the current loop |
| Under Voltage (HW) | The actual bus voltage is below the minimum allowed bus voltage |
| Over Voltage (HW) | The actual bus voltage is above the maximum allowed bus voltage |
| Drive Over Temperature | The internal drive temperature has reached the maximum allowed temperature |

**System Protection Status:** system related errors that are detected by the drive.

| Event | Description |
|---|---|
| Parameter Restore Error | Checksum error during parameter loading from non-volatile memory. |
| Parameter Store Error | Checksum error during parameter loading to non-volatile memory. |
| Invalid Hall State | Invalid state of the Hall sensor inputs |
| Phase Sync. Error | Improper commutation synchronization. Phase synchronization occurs with sinusoidally commutated motors either during encoder index (default) or hall edge. If an incorrect number of encoder counts is measured between synchronization edges, a Phase Sync. Error will occur. |
| Motor Over Temperature | Effective only if the motor temperature sensor is connected to an input on the drive and the Motor Over Temperature function is selected for that input |
| Phase Detection Fault | Effective only if the commutation is based on an incremental encoder only |
| Feedback Sensor Error: | Indicates a malfunction of the feedback sensor (e.g. encoder or resolver). |
| Motor Over-speed | The motor has exceeded the maximum specified speed |
| Upper Measured Position Limit: | The measured position has exceeded the maximum limit. |
| Lower Measured Position Limit: | The measured position has exceeded the minimum limit |

**Drive System Status:** internal drive status (does not necessarily correspond to a drive fault status, but could relate to a system error).

| **Event** | **Description** |
|---|---|
| Log Entry Missed | An event was not properly stored in the history log |
| Commanded Inhibit: | Indicates a drive inhibit event via the communication interface. |
| User Inhibit: | Indicates a drive inhibit event via a digital input |
| Positive Limit: | Indicates a drive inhibit event in the positive direction |
| Negative Limit: | Indicates a drive inhibit event in the negative direction |
| Current Limiting | Indicates a current limiting event as a result of the current limit settings |
| Continuous Current | Indicates that the actual output current has been reduced to the continuous current setting. |
| Current Loop Saturated | Indicates maximum PWM duty cycle as a result of saturation in the current loop |
| User Under Voltage | Indicates that the actual bus voltage is below the user defined under voltage limit. |
| User Over Voltage: | Indicates that the actual bus voltage is above the user defined over voltage limit. |
| Homing Complete | Homing has finished. |
| Commanded Quick Stop | Indicates a quick stop event via the communication interface. |
| User Quick Stop | Indicates a quick stop event via a digital input. |
| Position Following Error | Indicates an excessive position error in the position loop |
| Upper Target Position Limit | Indicates that the target position has reached the positive target position limit |
| Lower Target Position Limit | Indicates that the target position has reached the negative target position limit. |
| Load Measured Position | Indicates that the measured position is being loaded with the Measured Position Substitute value |
| Homing Active | Homing is being performed. |
| Apply Brake | The brake output has been activated. |

| **Event** | **Description** |
|---|---|
| PVT Buffer Full | The PVT buffer cannot accept any more information. |
| PVT Buffer Empty | The PVT buffer contains no more information |
| PVT Buffer Threshold Exceed | The PVT threshold has been reached as defined in the PVT Input Settings window . |
| PVT Buffer Failure | An error has occurred while retrieving PVT information from the buffer. |
| PVT Buffer Empty Stop | The PVT buffer has run out before a valid PVT stop point was sent. |
| PVT Sequence Number | PVT trajectory points were received out of order (can indicate a missing PVT point or repeated point). |
| Comm Channel Error | Used exclusively with CANopen drives. This event is triggered by failure to recieve a node-guard message within the specified life time of the drive. See CANopen manual for more information on Node Guarding and Life Guarding. |
| Non-Sinusoidal Commutation | Indicates that the drive is no longer in sinusoidal commutation mode |
| Phase Detection | Indicates that the drive is performing phase detection |
| Commanded Dynamic Brake | Indicates a dynamic brake event via the communication interface |
| User Dynamic Brake: | Indicates a dynamic brake event via a digital input |
| Shunt Regulator | Indicates the shunt regulator circuit is active |
| Phase Detection Complete: | Indicates the phase detect routine has finished |
| Zero Velocity | Indicates that the measured motor velocity is within the zero velocity window |

| Event | Description |
|---|---|
| At Command | Indicates that the measured motor velocity has reached the commanded velocity, within the At Velocity window (in velocity mode) or that the measured position has reached the target position, within the In Position window (in position mode). |
| Velocity Following Error | Indicates an excessive velocity error in the velocity loop |
| Positive Target Velocity Limit | Indicates that the target velocity has reached the positive velocity limit. |
| Negative Target Velocity Limit | Indicates that the target velocity has reached the negative velocity limit |
| Command Profiler Active | Indicates that the command profiler is active (i.e. is applying the user entered rate limits). |
| At Home Position | Indicates that the measured position has reached the Home Position, within the In Home Position Window |

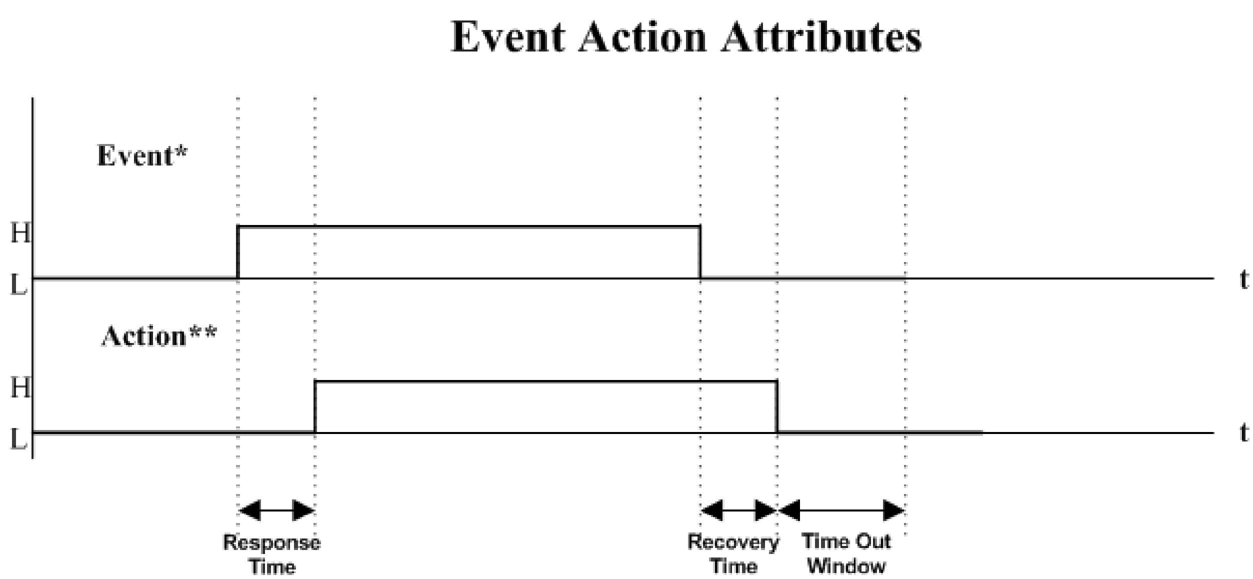
This window shows both the present state of each event and the history (indicating whether the event has occurred since the last reset or since power-up). Individual events can be selected for reset, or all events can be selected for reset. The actual resetting of an event depends on the event settings for that particular event, according to the settings in the Drive Control window. A reset will reset both the present state and history of the event (presuming the cause of the event is no longer present).

If you select the Commanded Inhibit event for reset, this will NOT enable the drive. Only the Enable/Disable Drive button in the toolbar can be used to change the Commanded Inhibit state.

The Drive Status Window also has a Fault Log and a Fault Log Counter. The Fault Log contains a list of the faults that occurred and a time stamp (in milliseconds). The Fault Log Counter contains a list off all faults and events and the number of times they have occurred.

***Drive Control***

The Drive Control window allows configuration of event handling in the drive. Events can correspond to a fault, or a particular internal drive state. The events have several programmable attributes:




*Event- Drive event that requires attention (i.e, motor over speed). See event tables for description of drive events.

**Action-The action the drive will take when the specified event happens (i.e, disable bridge). See event action table for a description of actions.

- **Disabled:** the event handling can be disabled.
- **Event Action:** the action to be taken by the drive after the response time has elapsed. The table below shows the possible actions to choose from. For safety reasons some actions are not available with some events.

- **Response Time:** the time delay between the actual occurrence of the event and the event action.

- **Recovery Time:** the time after which the selected event action will be removed when the cause of the event is no longer present.
- **Time-out Window:** the time, after the recovery time and subsequent removal of the event action, during which the drive will NOT consider an occurrence of the event as a new occurrence. The Event Action will still be applied in case an event does occur within this window. However, that occurrence will not be counted as a new occurrence with regard to the Maximum Recoveries attribute.
- **Maximum Recoveries:** the maximum number of occurrences of the event prior to a permanent event action.
- **Unlimited Recoveries:** there is no limit to the number of occurrences of the event

| Event Action | Description |
| --- | --- |
| No Action | Event Action is disabled |
| Disable Power Bridge | No power is delivered to the motor. Motor is allowed to move freely. |
| Disable Positive Direction | Disables the drive from outputting to the motor in the positive direction, while allowing commanded motion in the negative direction. The result is dependent on the mode of operation. This action is not recommended in vertical applications because the load will be free to fall once the limit is activated. For vertical loads, we recommend using 'Positive Stop'. |
| Disable Negative Direction | Disables the drive from outputting to the motor in the negative direction, while allowing commanded motion in the positive direction. The result is dependent on the mode of operation. |
| Dynamic Brake | Motor leads are virtually shorted together internally. However, the bridge enables to protect motor by regulating motor current. |
| Positive Stop | If the drive is controlling velocity or position, the load decelerates according to the deceleration limit specified in Drive Configuration. Commanded motion in the in the positive direction has no affect. Motor continues to servo with zero command in the positive direction. |
| Negative Stop | If the drive is controlling velocity or position, the load decelerates according to the deceleration limit specified in Drive Configuration. Commanded motion in the in the negative direction has no affect. Motor continues to servo with zero command in the negative direction. |
| Stop | If the drive is controlling velocity or position, the load decelerates according to the deceleration limit specified in Drive Configuration. Commanded motion has no affect. Motor continues to servo with zero command. |
| Apply Brake then Disable Bridge | Brake output is turned on, then bridge is disabled. Delay is set in Drive Configuration. |
| Apply Brake then Dynamic Brake | Brake output is turned on, then dynamic brake is applied. Delay is set in Drive Configuration. |

Note: some of the above mentioned attributes are not programmable for certain events.
Events are grouped in the following categories:

**Drive Protection**

| Event | Description |
|---|---|
| Short Circuit | Short-circuit condition of the power output stage |
| Hard Under Voltage | DC bus voltage below the drive hardware under voltage limit. |
| Hard Over Voltage: | DC bus voltage above the drive hardware over voltage limit |
| Drive Over Temperature | Drive internal temperature exceeded the maximum drive temperature limit |
| Parameter Restore Error: | An error during parameter download from non-volatile memory |
| Parameter Store Error | An error during parameter upload to non-volatile memory |
| Communication Error | Error during communication between drive and PC. |

**Voltage & Temperature:**

| Event | Description |
|---|---|
| Motor Over Temperature | Applicable only when a motor temperature sensor is connected to a programmable input (analog or digital) with the Motor Over Temperature function. The event corresponds to this input becoming active. |
| User Under Voltage | DC bus voltage below the User Under Voltage Limit setting (see Drive Configuration). |
| User Over Voltage | DC bus voltage above the User Over Voltage Limit setting (see Drive Configuration). |
| Shunt Regulator | DC bus voltage above the Shunt Turn-on Voltage setting (see Drive Configuration). Effective only on drive models with built-in shunt regulator. |

**Bridge Control**

| Event | Description |
|---|---|
| Commanded Inhibit | An inhibit command over the communications interface (active when the stop light icon is red). |
| User Inhibit: | An inhibit command from a digital input. |
| Positive Limit: | A positive inhibit command from the communications interface or a digital input. |
| Negative Limit | A negative inhibit command from the communications interface or a digital input. |
| Commanded Dynamic Brake: | A dynamic brake command over the communications interface. |
| User Dynamic Brake | A dynamic brake command from a digital input. |
| Commanded Quick Stop | A quick stop event via the communication interface |
| User Quick Stop | A quick stop event via a digital input. |

**Current Control Events**

| Event | Description |
|---|---|
| Current Limiting | The drive is commencing current limiting (based on the current limit settings). |
| Continuous Current | The drive has reached the continuous current setting, after current limiting. |
| Current Loop Saturated | The maximum PWM duty cycle has been reached due to current loop saturation. |
| Current Overshoot | The drive output current has exceeded the maximum drive rating. |

**Commutation Control**

| Event | Description |
|---|---|
| Non-sinusoidal Commutation | The drive is not commutating sinusoidally. This event occurs automatically upon power-up before the motor has moved around. Otherwise, this may be due to loss of synchronization or saturation, or the drive may be set for trapezoidal commutation. |
| Phase Detection | The drive is going into phase detection mode (phasing based on the encoder only feedback). |
| Invalid Hall State | An invalid state of the hall sensors has been detected. |
| Phase Synchronization Error | A synchronization loss due to a missing Hall sensor or encoder index edge has occurred. |
| Feedback Sensor Error | A feedback sensor error (e.g. missing encoder, bad resolver, etc.) has occurred. |
| Phase Detection Failure | The phase detection algorithm did not properly complete. |
| Phase Detection Complete | The phase detection algorithm is complete. |

**Velocity Events**

| Event | Description |
|---|---|
| Motor Over Speed | The measured motor velocity has exceeded the motor over speed limit. |
| Zero Velocity | The measured motor velocity is within the Zero Velocity window. |
| Velocity Following Error | The velocity following error exceeds the Velocity Following Error window. |
| Positive Velocity Limit: | The demand velocity has reached the Positive Velocity limit. |
| Negative Velocity Limit | The demand velocity has reached the Negative Velocity limit |

**Command Events**

| Event | Description |
|---|---|
| Command Profiler Active | The<br>Command Profiler is affecting the target signal (i.e. rate limiting). |
| At Command | The measured motor velocity has reached the target velocity, within the At Velocity Window (found in Drive Configuration ). |
| Load Target | The target value has been replaced with the predefined target position. |
| PVT Buffer Full | The PVT buffer cannot accept any more information. |
| PVT Buffer Empty | The PVT buffer contains no more information |
| PVT Buffer Threshold | The PVT threshold has been reached as defined in the PVT command type window. |
| PVT Buffer Failure | An error has occurred while retrieving PVT information from the buffer. |
| PVT Buffer Empty Stop | The PVT buffer has run out before a valid PVT stop point was sent. |
| PVT Sequence Number | PVT trajectory points were received out of order (can indicate a missing PVT point or repeated point). |

**Position Events**

| Event | Description |
|---|---|
| Max Measured Position: | The measured position has exceeded the Max Measured Position limit. |
| Min Measured Position | The measured position has exceeding the Min Measured Position limit. |
| At Home Position | The measured position has reached the Home Position value, within the In Home Position Window. |
| Position Following Error | The position following error has exceeded the Position Following Error limit. |
| Max Target Position | The demand position has reached the Max Target Position limit. |
| Min Target Position | The demand position has reached the Min Target Position limit. |
| Load Measured Position | The measured position value has been replaced with the Measured Position Substitute value. |
| Homing active | Homing is being performed. |
| Homing complete | Homing has finished. |

**Communication**

| Event | Description |
|---|---|
| Communication Error | Used exclusively with CANopen drives. This event is triggered by failure to recieve a node-guard message within the specified life time of the drive. See CANopen manual for more information on Node Guarding and Life Guarding. |