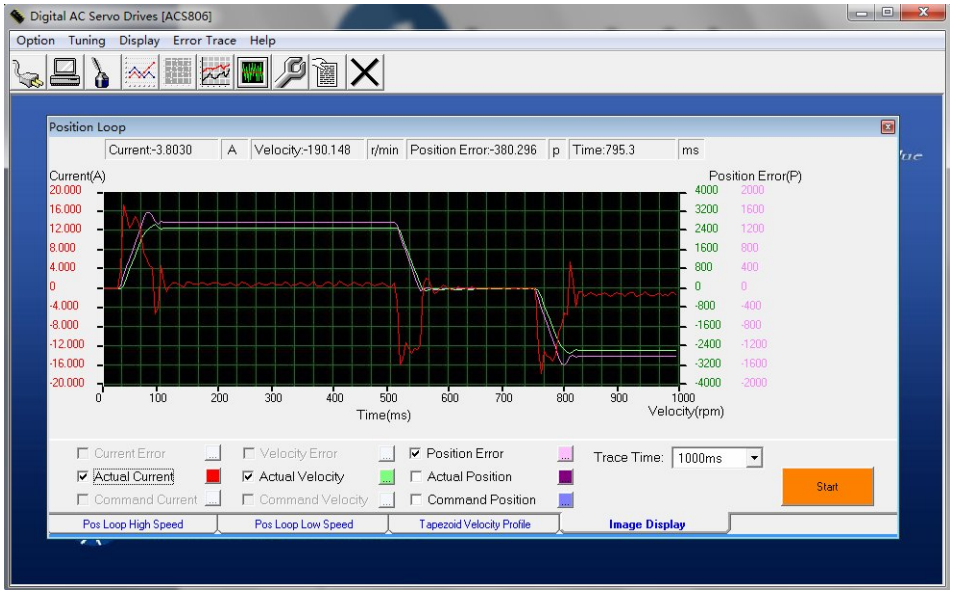
# Software Manual

## Of the ACS306, ACS606 V2.0 & ACS806 V2.0




Version 0.0.0

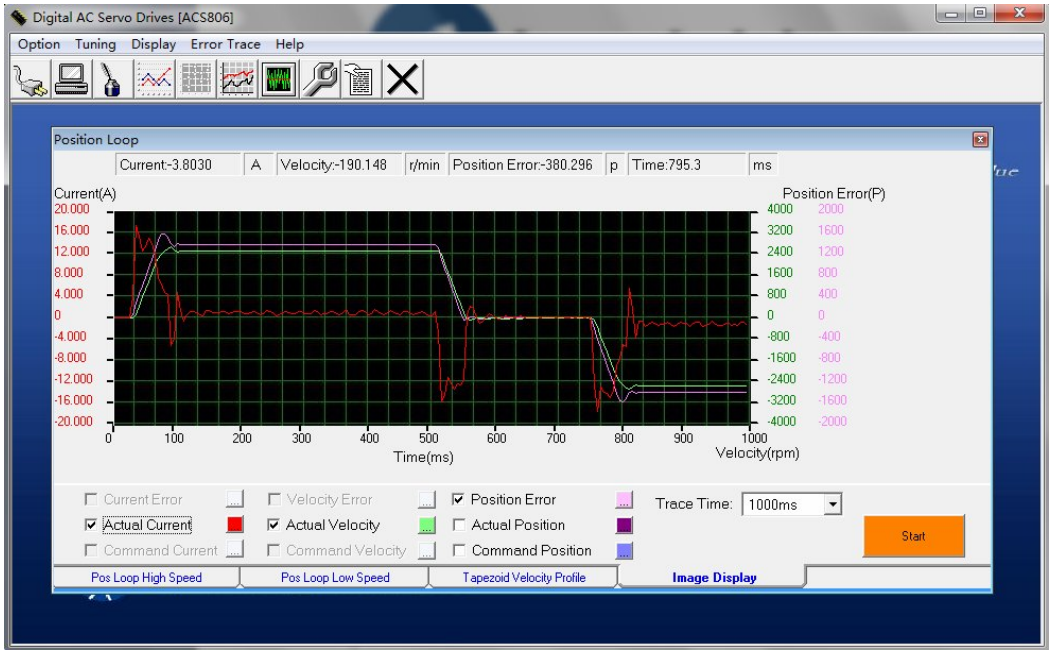
http://www.Leadshine.com

# *Table of Contents*

# Introduction

This document provides necessary information on how to use the setup software to configure and tune the leadshine's AC brushless servo drive ACS306, ACS606 V2.0 and ACS806 V2.0.

# Workspace




Menu & Toolbar

Configuration / Tuning Window

# Menus and Toolbar

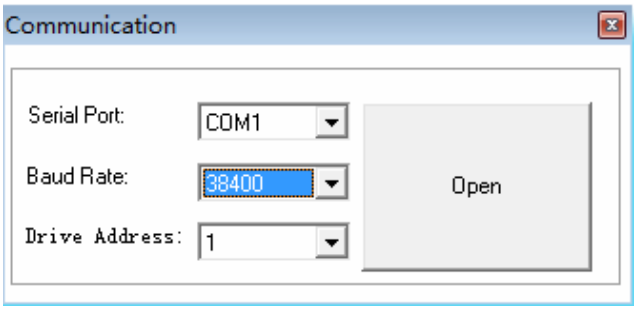
Menus and toolbars are at the top of the workspace. You can click the menu bar to view the pull-down menu. The toolbar provides the most frequency used commands.

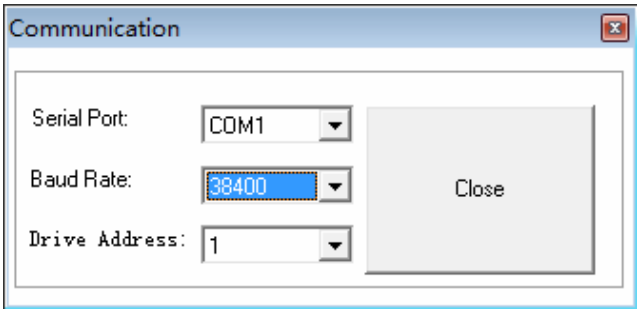
# Menus and Toolbar (Continued)

| Menu | Pull Down | Toolbar | Function |
|---|---|---|---|
| Option -> | Communication |  | Open the serial port and connect to drive |
| | Exit |  | Exit from the setup software |
| Tuning-> | Configuration |  | Configure the operating mode, I/O, filter, motor & feedback parameters |
| | Current Loop |  | Tune the current loop parameters |
| | Velocity Loop |  | Tune the velocity loop parameters |
| | Position Loop |  | Tune the position loop parameters |
| Display-> | Show Curves |  | Display the motion variables like position error, feedback velocity & current |
| | Show Parameters |  | Parameter list |
| Error Trace-> | - |  | Check drive error(s) |
| Help-> | Product Information |  | Setup software information |

# *Using the Software*

## *Connecting Drive*




Click Option -> Communication to open the "Communication" window. Select the serial port number and click on the Open button. The baud rate must be 38400 for the ACS306, ACS606 V2.0 and ACS806 v2.0. The software will try to communication with the drive. It may take several minutes.


Before connecting the drive, please make sure:

1) The RS232 cable has been connected between the drive and PC serial port.
2) The power supply has been applied to the drive. The green LED is on.

The motor is needn't be connect to the drive if you just want to configure the parameters.

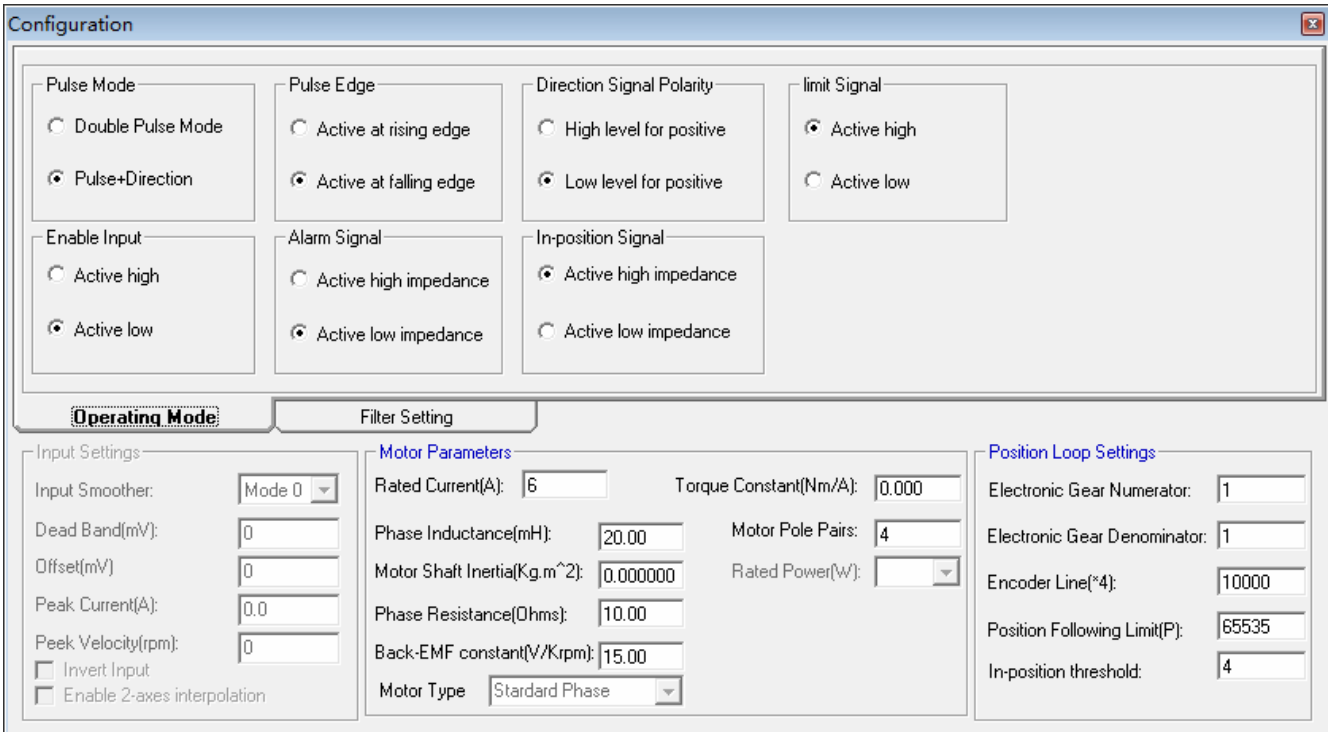

Do not connect or disconnect the RS232 communication cable when powered is on.

## *Configuration Window*

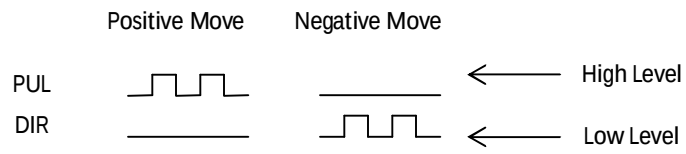
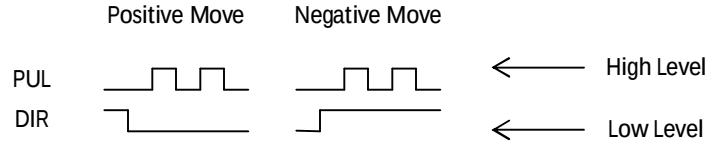
To open the "Configuration" window, click Tuning -> Configuration on the menu bar. In the "Configuration" window, the parameters are separated into three regions. The 1st region is the "Operating Mode" tab. The 2nd region is the "Filter Setting" tab and the 3rd region is at the half bottom of the whole window.

### *Operating Mode Tab*

In the "operating mode" tab you can select the pulse mode (type) and the active level/edge of the digital inputs/outputs. The table below provides detailed information for each option.




Operating Mode tab- Input and output parameters

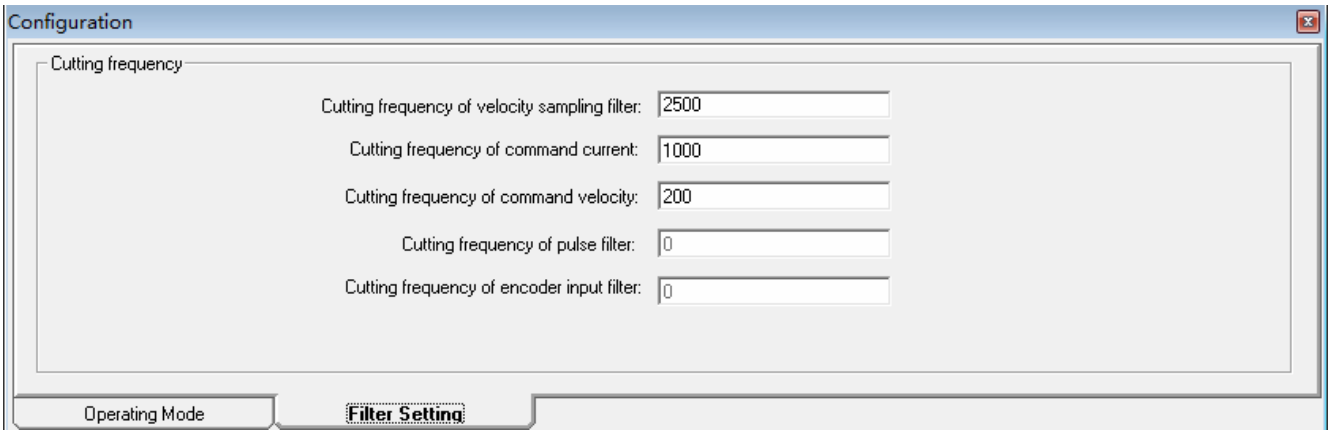
| | |
|---|---|
| Pulse Mode | Double Pulse Mode :<br>  |
| | Pulse + Direction :<br>  |

Operating Mode tab - Input and output parameters (Continued)

| | |
|---|---|
| Pulse Edge | Specifies the active edge of the pulse signal. The motor moves one micro step at each active edge of the pulse signal. Note that the actual setting is also related to the connection circuitry between the drive's input and the controller's output. For example, the PNP (sourcing) connection is on the converse to the NPN (sinking) connection. |
| Direction Signal Polarity | This option affects the actual motion direction as per the DIR signal level. You can use it to change the rotation direction when it is converse. |
| Limit Signal | Specifies the active level of the end limit inputs. |
| Enable Input | Specifies the active level of the enable input. |
| Alarm Signal | Specifies the active impedance of the alarm output. |
| In-position Signal | Specifies the active impedance of the in-position (Pend) output. |

### *Filter Setting Tab*

In the "Filter Setting" tab, you can specify the cutting frequency for the digital filters. The table below provides detailed information for each parameter. Note that the default value of those parameters is suitable for most of the applications. It is unnecessary to change the default value if the motion system works well.




Filter Setting Tab – Cutting frequency of the filter

| | |
|---|---|
| Cutting frequency of the velocity sampling filter | Specifies the cutting frequency of the velocity sampling filter. Make it as high as possible but big value will introduce high motor noise. |
| Cutting frequency of command current | Specifies the cutting frequency of the command current. Make it as high as possible but big value will introduce high motor noise. Too low value may lead to motor vibration. |
| Cutting frequency of command velocity | Specifies the cutting frequency of the velocity command velocity |
| Cutting frequency of pulse filter | Specifies the cutting frequency of the pulse filter |
| Cutting frequency of encoder input filter | Specifies the active impedance of the encoder input filter. |

*Motor Parameters*

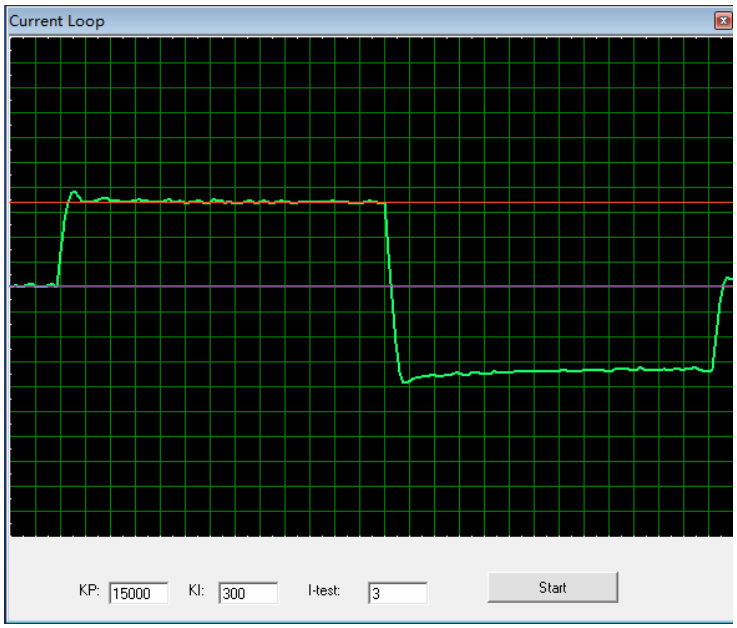
| | |
|---|---|
| Rated Current (A) | Specifies the motor's rated (continued) current. It is actually the drive's continuous current limit. |
| Phase Inductance (mH ) | Specifies the motor's phase inductance. |
| Motor Shaft Inertia (Kg.m^2) | Specifies the inertia of the motor shaft |
| Phase Resistance(Ohms) | Specifies the phase resistance of the motor |
| Back-EMF constant (V/Krpm) | Specifies the back-EMF constant of the motor |
| Motor Type | Specifies the communication type of the motor |
| Torque Constant (Nm/A) | Specifies the torque constant of the motor |
| Motor Pole Pairs | Specifies the pole pairs of the motor. It is the motor poles divided by 2. |
| Rated Power (W) | Specifies the rated power of the motor. |

## *Current Loop Window*

To open the "Current Loop" window, click Tuning -> Current Loop on the menu bar. In the "Current Loop" window, you can adjust the Kp (proportional gain) and Ki (integral gain) then start a step test. The window will display a green curve which represents the actual motor current to indicate the test result.

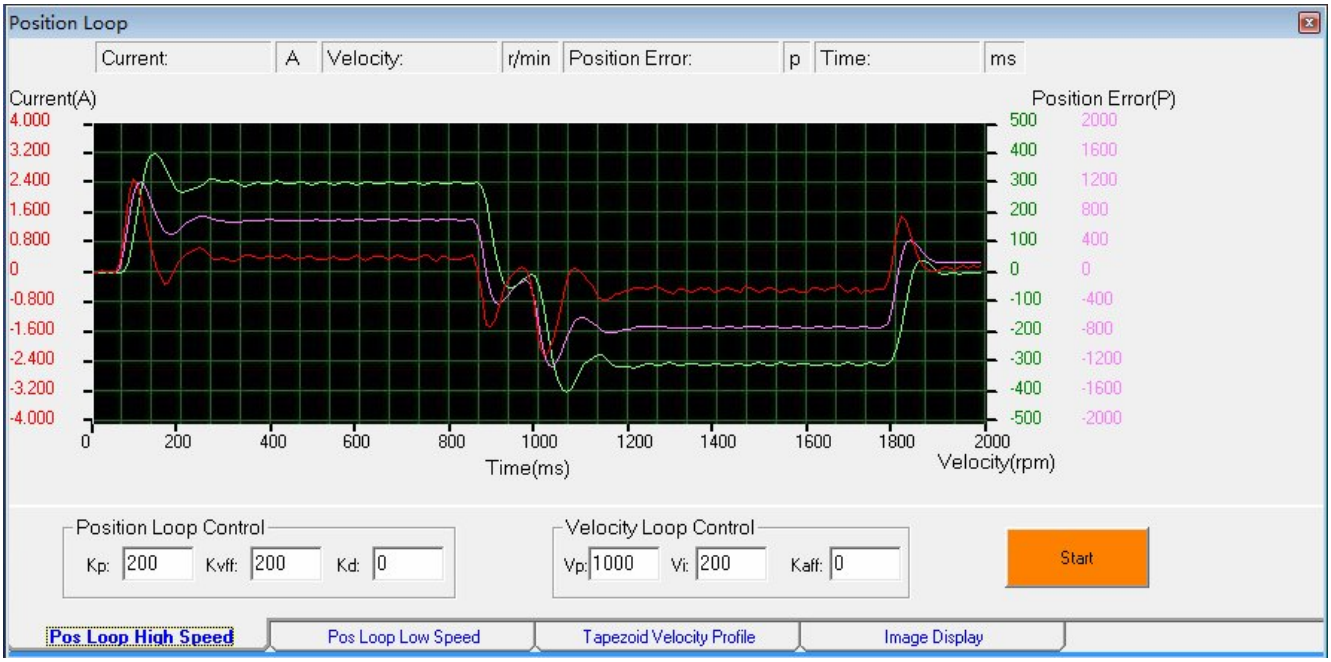
Current loop tuning parameters

| | |
|---|---|
| KP | Proportional gain of the current loop. Increase it to make the current rise fast. |
| KI | Integral gain of the current loop. Set a proper value to lower down the difference between the red curve (target current) and the green curve (feedback current). |
| I-test | Test current value. It should be greater than 0.5A and less than the motor's continuous current. |
| Start | Click this button to issue a step command to the current loop |



## *Position Loop Window*

To open the "Position Loop" window, click Tuning -> Potion Loop on the menu bar. In the "Position Loop" window, you can adjust PID parameters and then start a trapezoid velocity motion to view the effect the PID parameters. The window will display the actual current curve, the actual velocity curve and the position error curve for each trapezoid velocity motion test. There are two gain sets for the PID parameters. One is for the low-speed (standstill) performance and the other is for the high-speed (dynamic) performance. These two gain sets are separated into the "Pos Loop Low Speed" tab and the "Pos Loop High Speed" tab, respectively.




### *Pos Loop High Speed Tab*

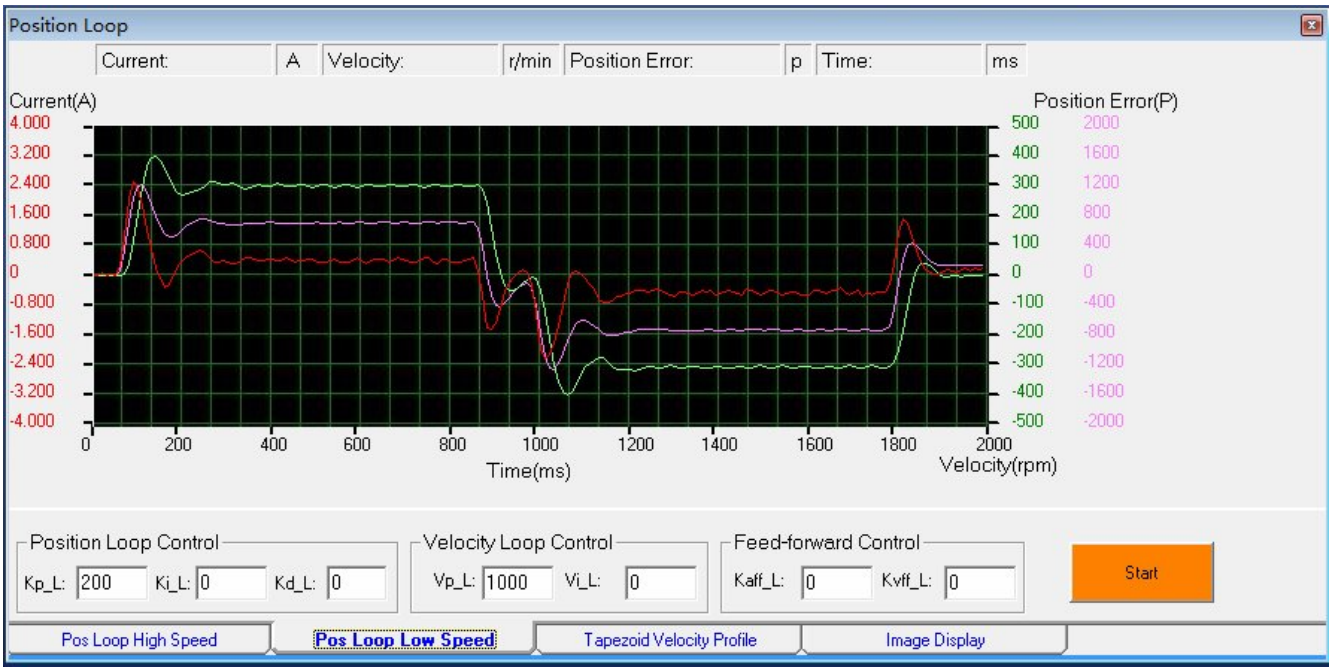
The configuration in the "Pos Loop High Speed Tab" tab affects the dynamic performance of the drive's position loop. When the motor starts to move, the PID parameters in this tab starts to take effect.

| Position Loop Control (Dynamic performance) | |
|---|---|
| Kp | Proportional gain of the high-speed position loop. Increase it to make the actual motor position response fast. |
| Kvff | Velocity feed-forward gain of the high-speed position loop. |
| Kd | Derivative gain of the high-speed position loop. |

| Velocity Loop Control (Dynamic performance) | |
|---|---|
| Vp | Proportional gain of the high-speed velocity loop. Increase it to make the actual motor velocity response fast. |
| Vi | Integral gain of the high-speed velocity loop. |
| Kaff | Acceleration feed-forward gain of the high-speed velocity loop. |

*Pos Loop Low Speed Tab*

The configuration in the "Pos Loop Low Speed Tab" affects the standstill performance of the drive's position loop. When the motor starts to move, the PID parameters in this tab starts to take effect.



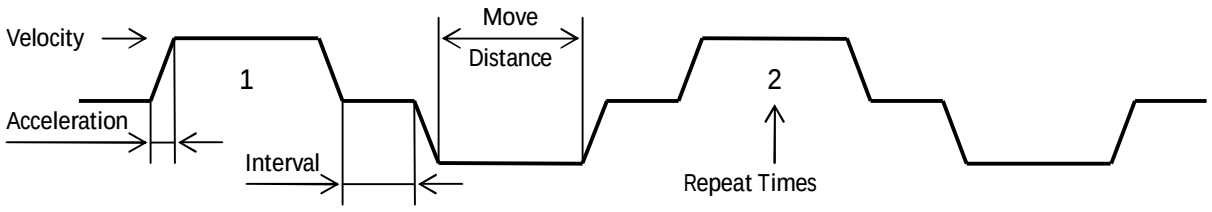

| Position Loop Control (Standstill performance) | |
|---|---|
| Kp_L | Proportional gain of the low-speed position loop. Increase it to make the actual motor position response fast. |
| Ki_L | Integral gain of the low-speed position loop. |
| Kd_L | Derivative gain of the low-speed position loop. |

| Velocity Loop Control (Standstill performance) | |
|---|---|
| Vp_L | Proportional gain of the low-speed velocity loop. Increase it to make the actual motor velocity response fast |
| Vi_L | Integral gain of the low-speed velocity loop |

| Feed-forward Control (Standstill performance) | |
|---|---|
| Kaff_L | Acceleration feed-forward gain of the low-speed position loop. |
| Kvff_L | Velocity feed-forward gain of the low-speed position loop. |

### *Trapezoid Velocity Profile Tab*

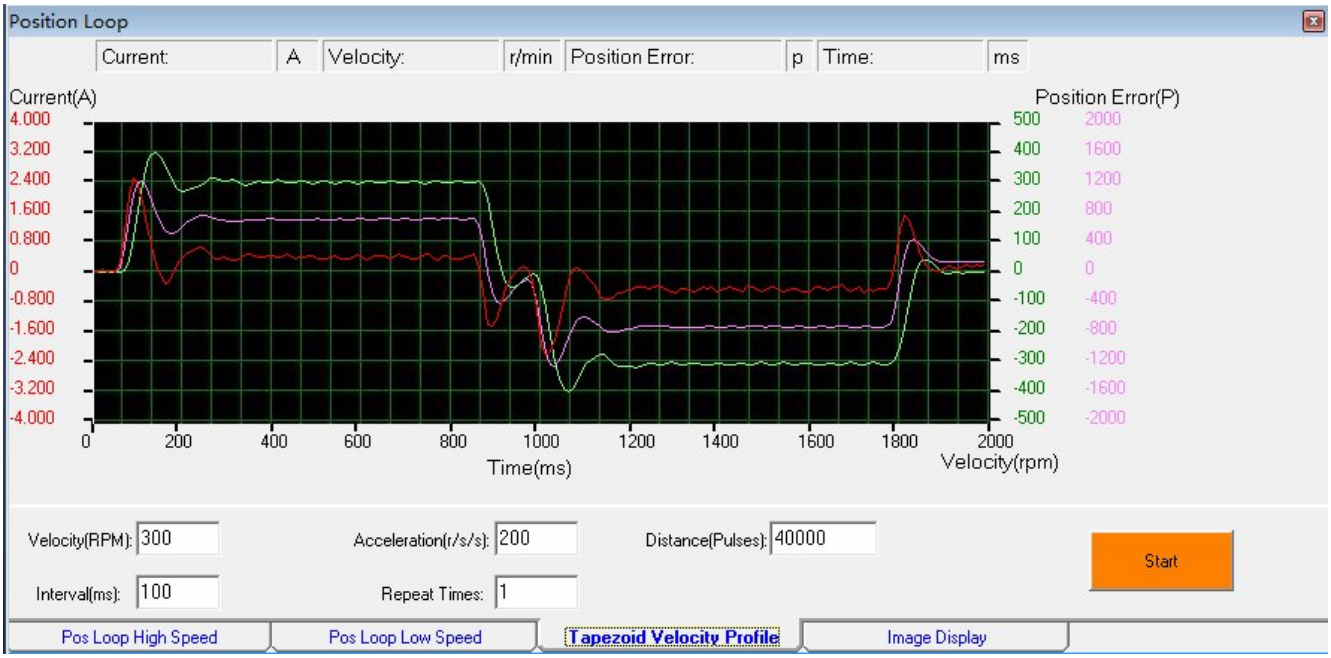
The motion test for the PID tuning is defined by the trapezoid velocity profile in the "Trapezoid Velocity Profile" tab. You can configure the velocity, acceleration, move distance, dwell and repeating times for the trapezoid motion.




Trapezoid Velocity Profile

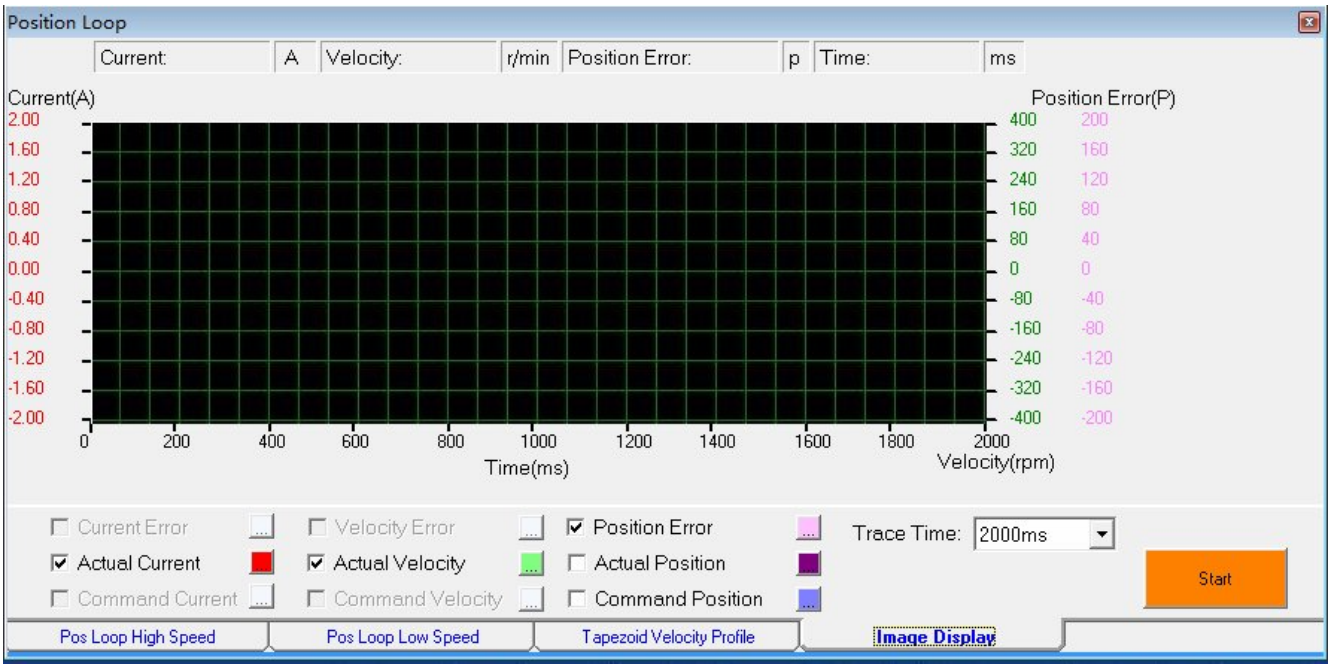
| | |
|---|---|
| Velocity (RPM) | Specifies the velocity of the trapezoid motion |
| Acceleration (r/s/s) | Specifies the acceleration of the trapezoid motion |
| Distance (Pulses) | Specifies the acceleration of the trapezoid motion |
| Inverval (ms) | Specifies the interval (dwell) of the trapezoid motion |
| Repeat Times | Specifies the repeat times of the trapezoid motion |

Trapezoid Velocity Profile Window



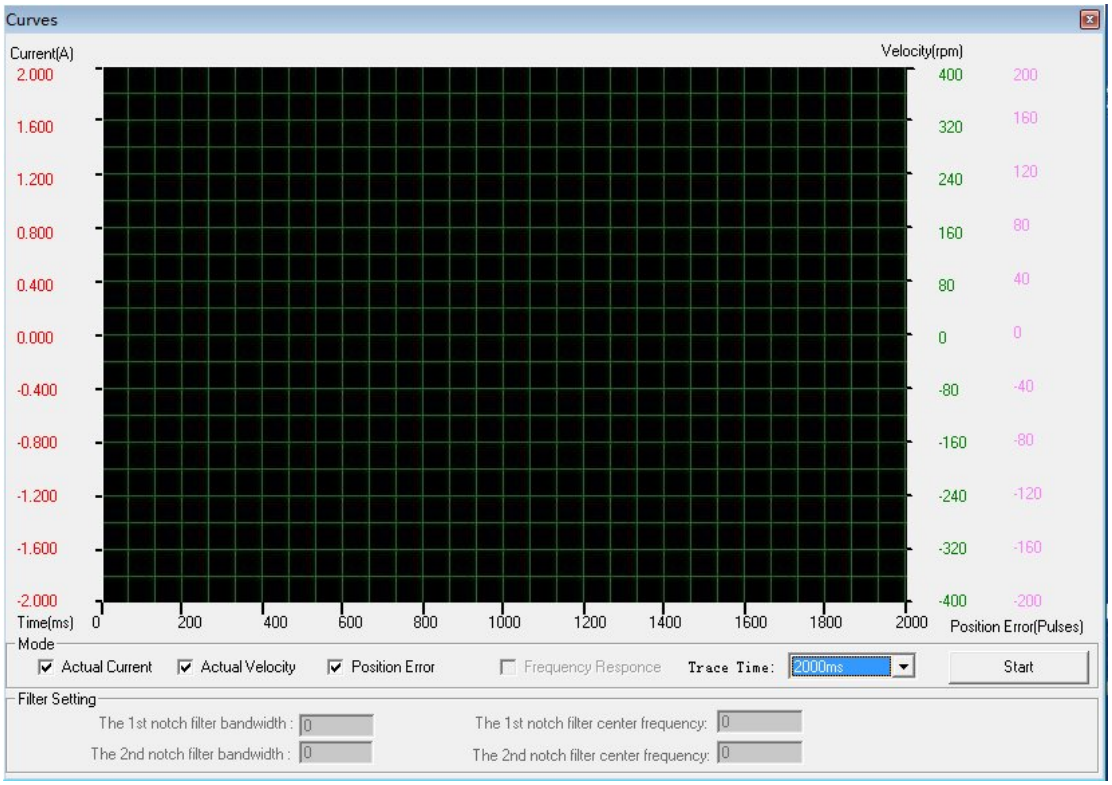

### *Image Display Tab*

In the "image display" tab, you can chouse which curve to be displayed and even change its color. The selectable curves are actual current, actual velocity, position error, actual position and command position. The sampling time for those curves is defined by the "Trace Time".




## *Show Curves Window*

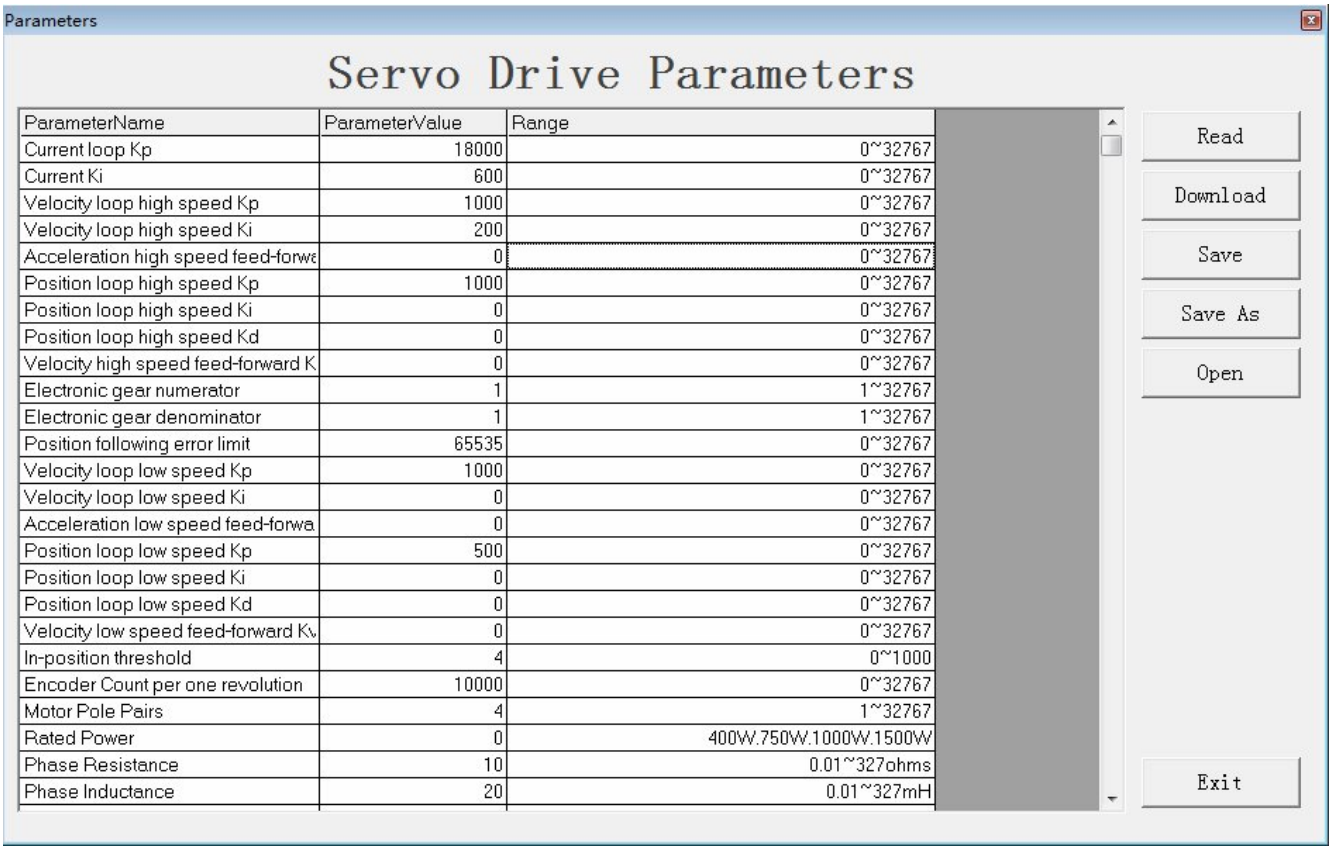
To open the "Show Curves" window, click Display-> Show Curves on the menu bar. You can use open this window to monitor the actual current, actual velocity and position error when the drive is controlled by external step/direction signal. Click the "Start" to start the monitoring of these selected curves. Click the "Stop" button to stop the monitoring.



## *Show Parameter Window*

To open the "Show Parameters" window, click Display-> Show Parameters on the menu bar. You can view the all configurable parameters in this window. However, the most significant functions of the "Show Parameters" window are:

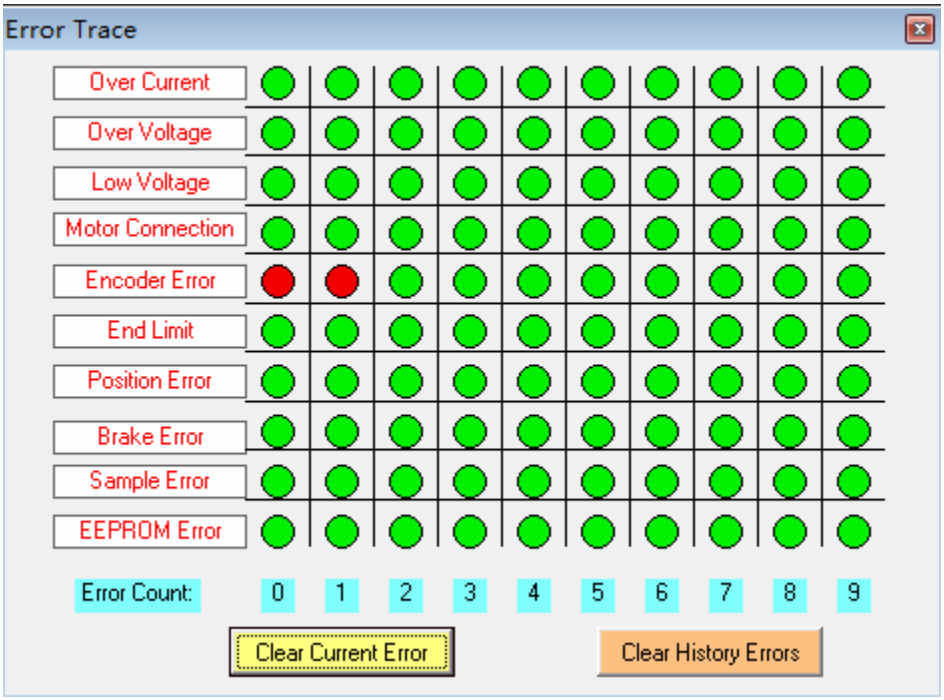
- Write the parameter values to the drive's EEPROM. Thus they will not be lost after repowering the drive.
- Save the parameters as a configuration file to the PC.




| | |
|---|---|
| Read | Read the parameter values from the drive |
| Download | Download the parameter values to the drive's RAM (will be lost after repowering the drive) |
| Save | Write the parameter values to the drive's EEPROM |
| Save As | Save the parameter values to a PC file (need to read the parameter first) |
| Open | Open a configuration file |

## *Error Trace Window*

To open the "Error Trace" window, click Error Trace on the menu bar. You can check the drive error status in this window. When there is drive error occurs (Red LED blinking), this window helps you figure out the cause of the problem.



# Configuring the Drive

Typically, you can follow the steps below to configure the drive.

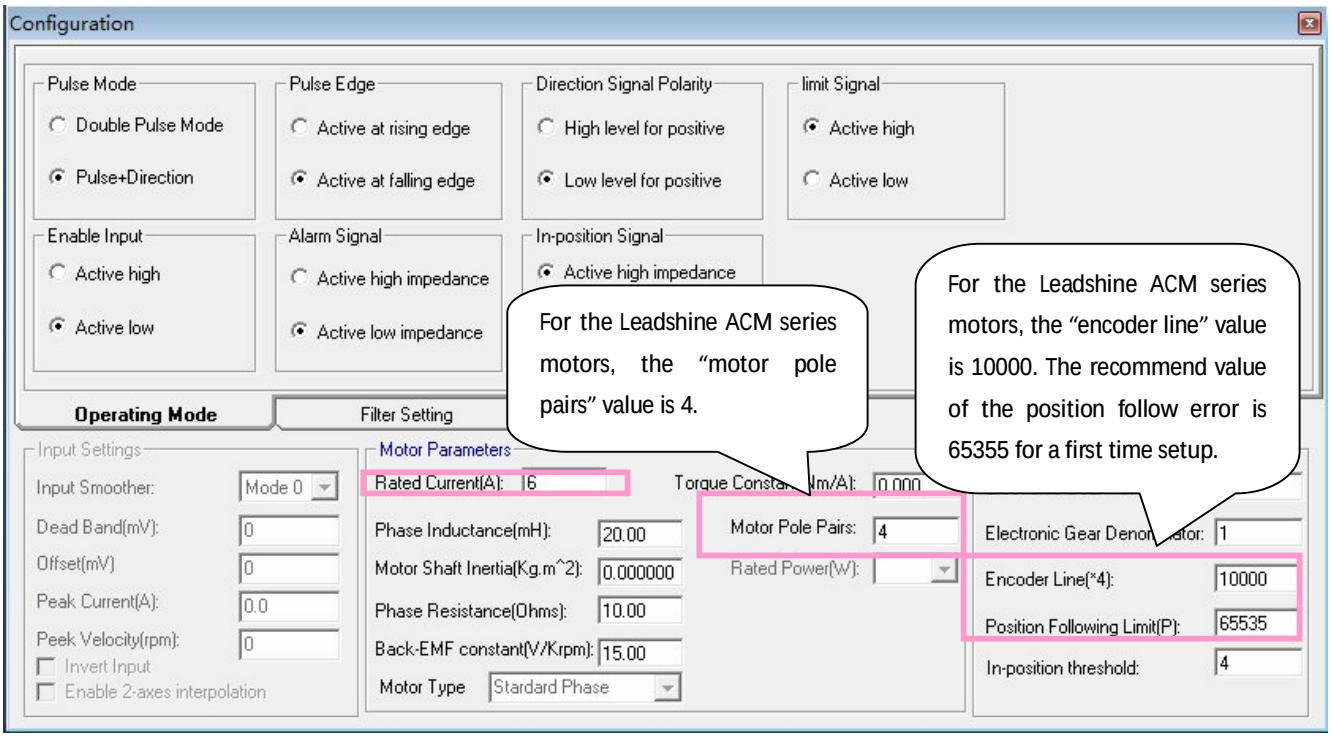
Step 1: Configure the motor parameters & position loop settings.
Step 2: Configure the inputs/outputs option according to the connection circuitary.
Step 3: Tune the current loop gain Kp and Ki according to the supply voltage and connecting motor.
Step 4: Tune the loop gains for the standstill performance according to the load.
Step 5: Tune the loop gains for the dynamic performance according to the load.
Step 6: Write parameters to Drive's EEPROM and save it to a PC file.

## Step 1: Configure the motor parameters and position loop settings

The motor parameters and position loop settings are very important for the drive to perform a correct operation. The most significant parameters are listed as follows:

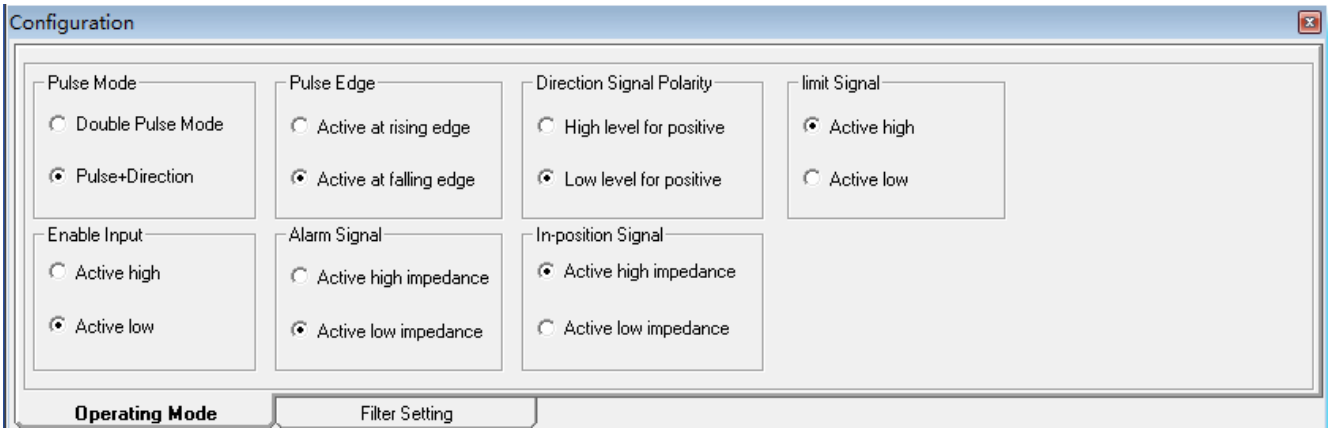
- The rated current which is actually the continuous current limit
- The pole pairs which affects the motor commutation
- The encoder line which is actually 4 times of the actual encoder lines
- The position following limit which defines the threshold of the position following error.

Click Tuning->Configuration to open the "configuration" window. These parameters and the recommended value can be found in the configuration window as follows.



## *Step 2: Configure the inputs/outputs options*

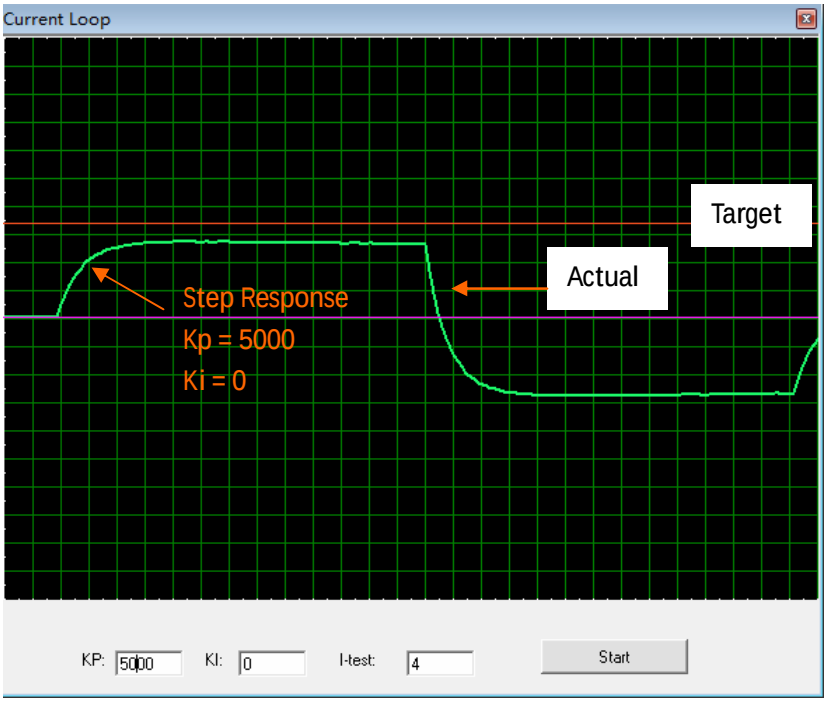
The ACS306, ACS606V2.0 and ACS806 V2.0 support the position mode only. Uses can apply either the pulse/direction command or the CW/CCW (double pulse) command to rotate the motor. The "pulse edge" option defines the active edge of the pulse input. The motor shaft rotates one micro step per each active edge. If the motion direction is not correct, try to toggle the "Direction Signal polarity" which represents the active level for the positive direction. There are also options for the active level the enable input, end limit input, alarm output and in-position (Pend) output.



## *Step 3: Tune the current loop gain Kp and Ki*

The following procedure illustrates the typical tuning process of the current loop based on the ACM602V36-2500 and the ACS806 V2.0 with a 36VDC power supply.

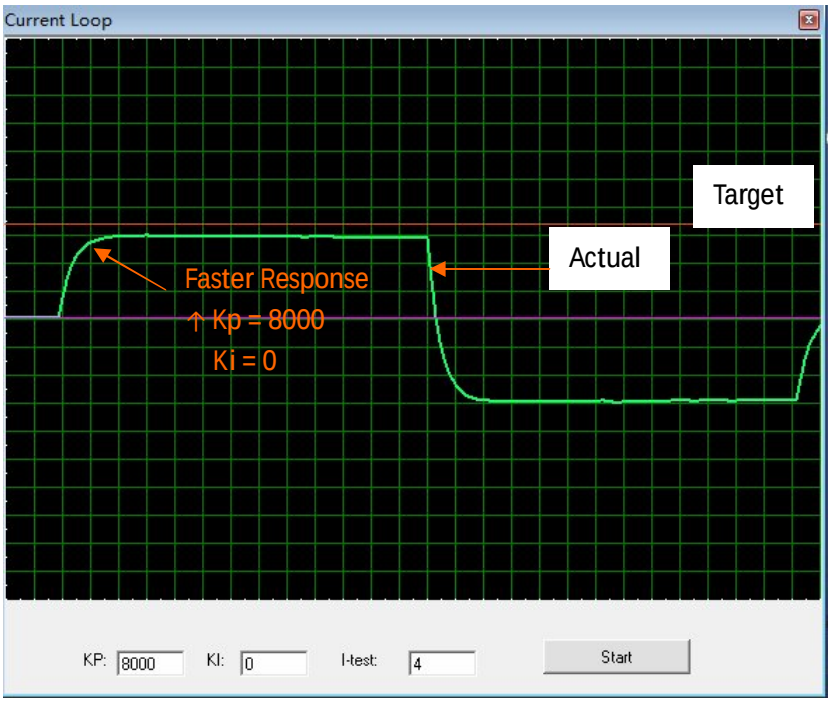
Step 3.1: Set "I-test" to 1 and start the tuning with small Kp and "zero" Ki. Here we set Kp = 5000 and Ki = 0. The "I-Test" is the amplitude of the target which is based on the required current for the application but it should be less than the motor's rated current. The recommended range for I-test is 20% to 50% of the rated current. Here we set it to 4A for the ACM602V36-2500.



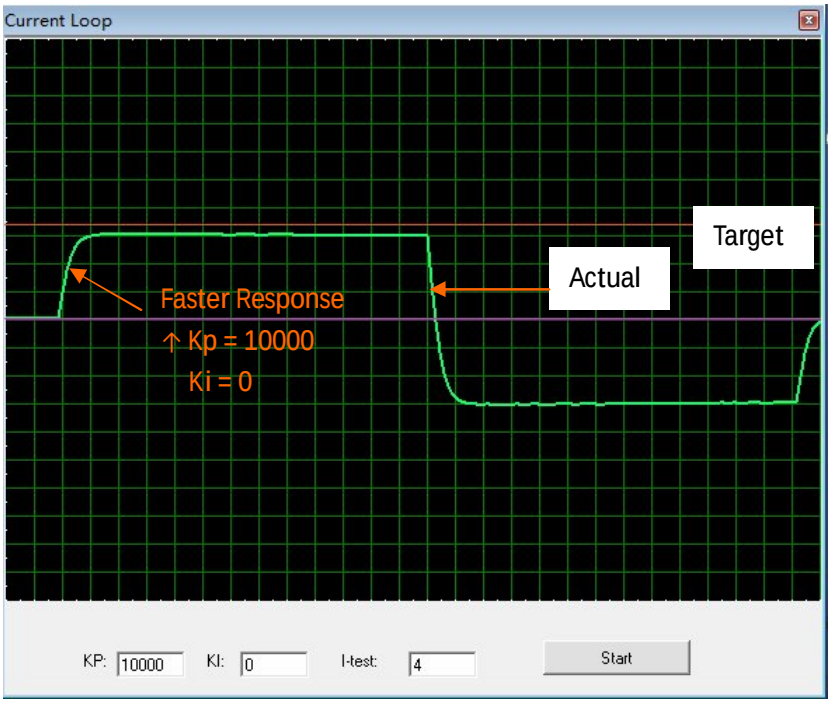

Step 3.2: Click the Start button and the plot window will show the step response of the current test. As the red curve increases from 0 to target slowly, it indicates that a large Kp needs to be introduced. If there has been big over shoot or vibration over the target line for your application, you need to set lower I-test value for the test.

Step 3.3: Increase Kp to 8000 and click Start. The red curve change faster from 0 to the target. Note that the increment for Kp is depending on the supply voltage, motor inductance and resistance. If you are not sure about it, just use a small value such as 100 at first then goes higher.

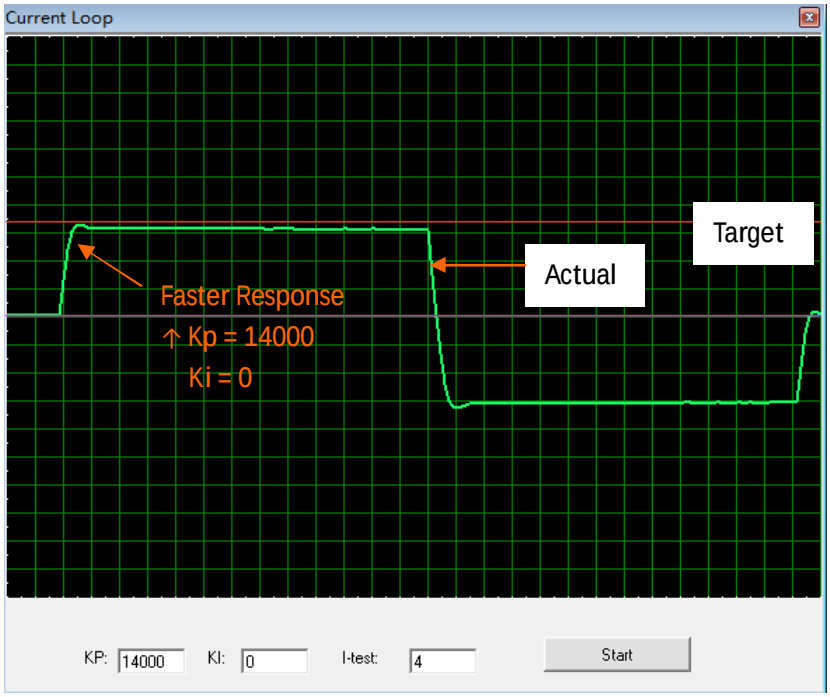
Step 3.3 (continued): Increase Kp of the current loop

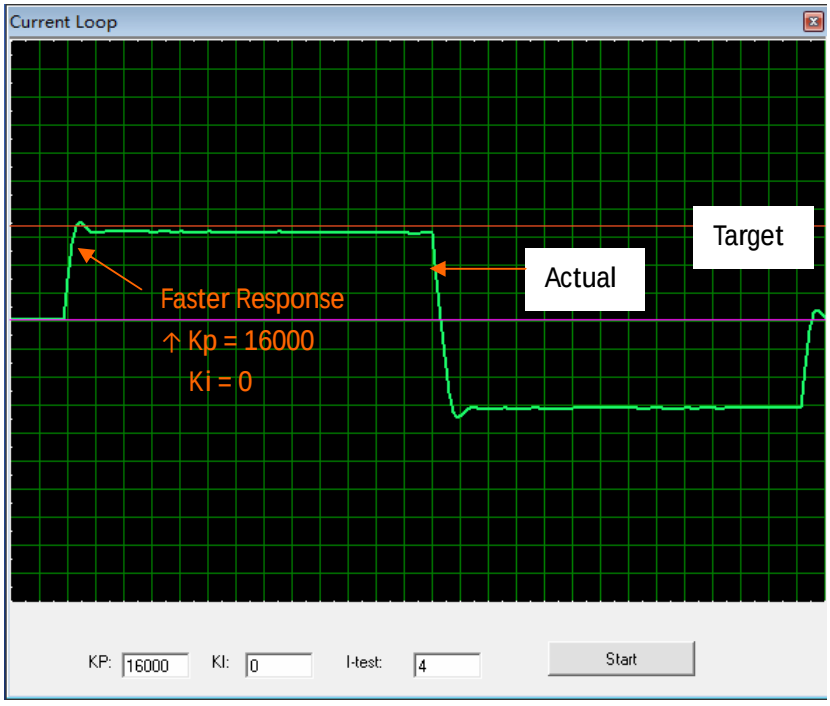



Step 3.4: Set Kp to 10000, 14000 and 18000, respectively. Then click the Start. The red curve is changing faster and faster. The over-shoot appears when Kp is 16000. It indicates that you need to stop increasing Kp and back off. So we decrease Kp to 16000 until the actual value is exactly over the target value.



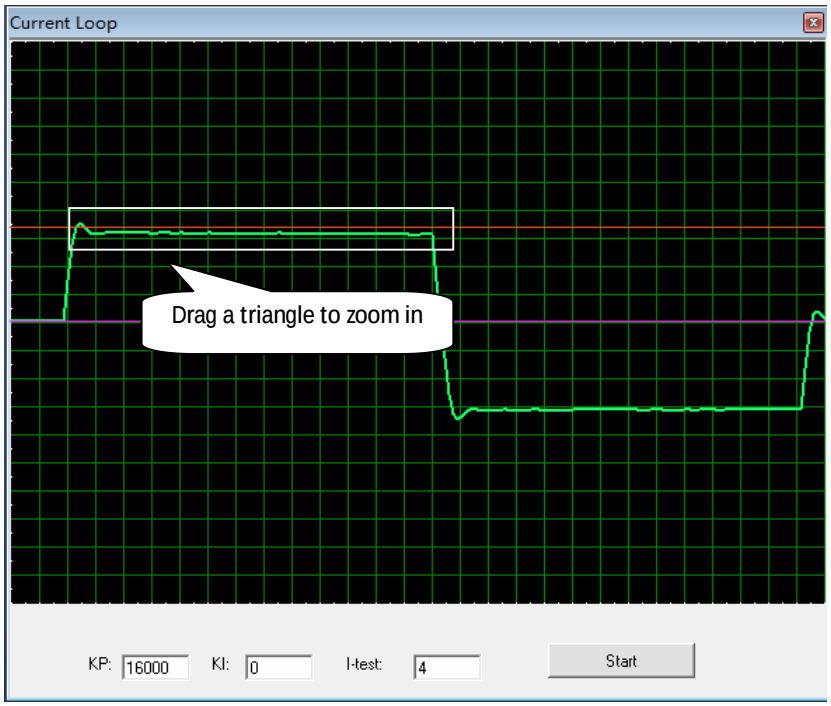
Step 3.4 (continued): Increase Kp of the current loop

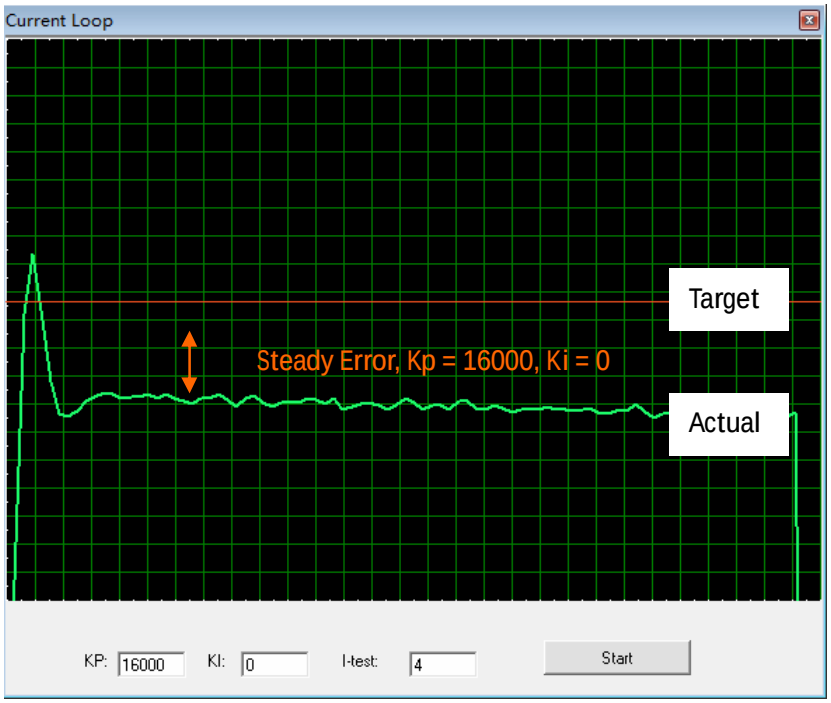


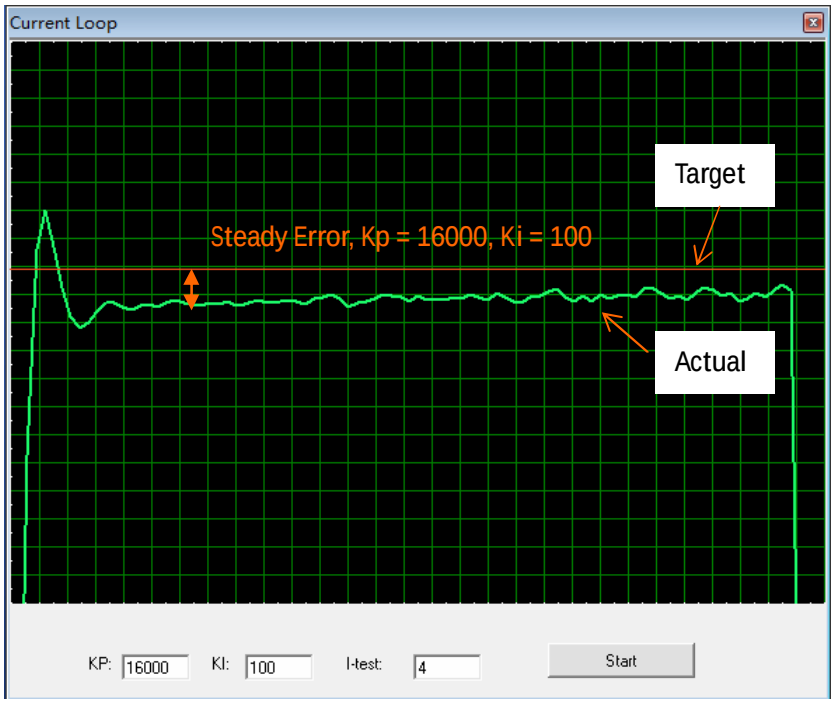

Step 3.5: Now the Kp is relatively good enough. But there is still error between the actual current and the target current. So we need to introduce Ki to reduce the steady error on the constant part. It follows the same procedure as Kp. High Ki causes big vibration, system lag and makes the performance worse. The following figures show how to tune the integral gain.

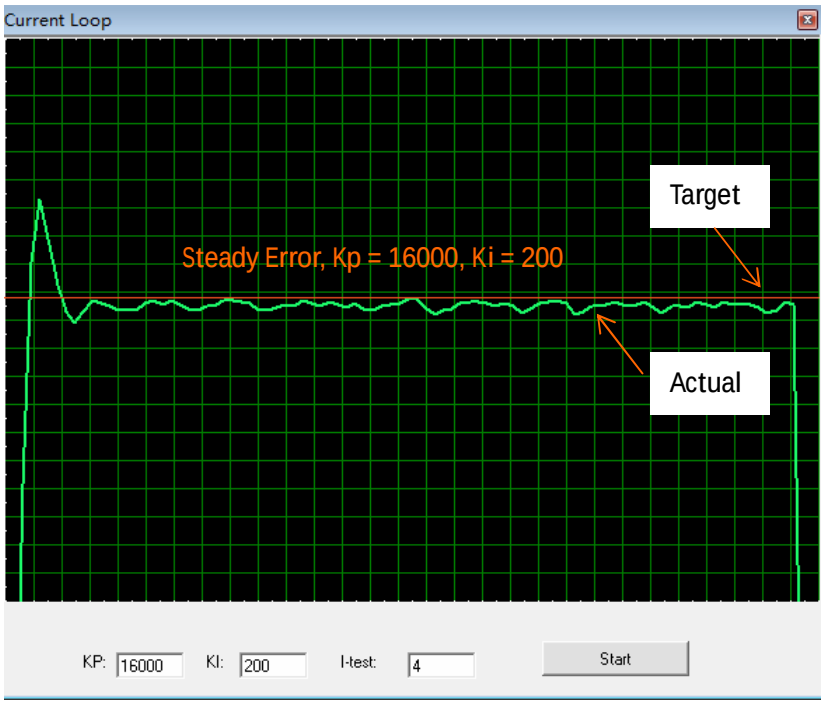
Step 3.5 (Continued): Increase current loop Ki



Step 3.5 (Continued): Increase current loop Ki




The current loop tuning is basically finished now. You can continue to adjust the Kp and the Ki if necessary.

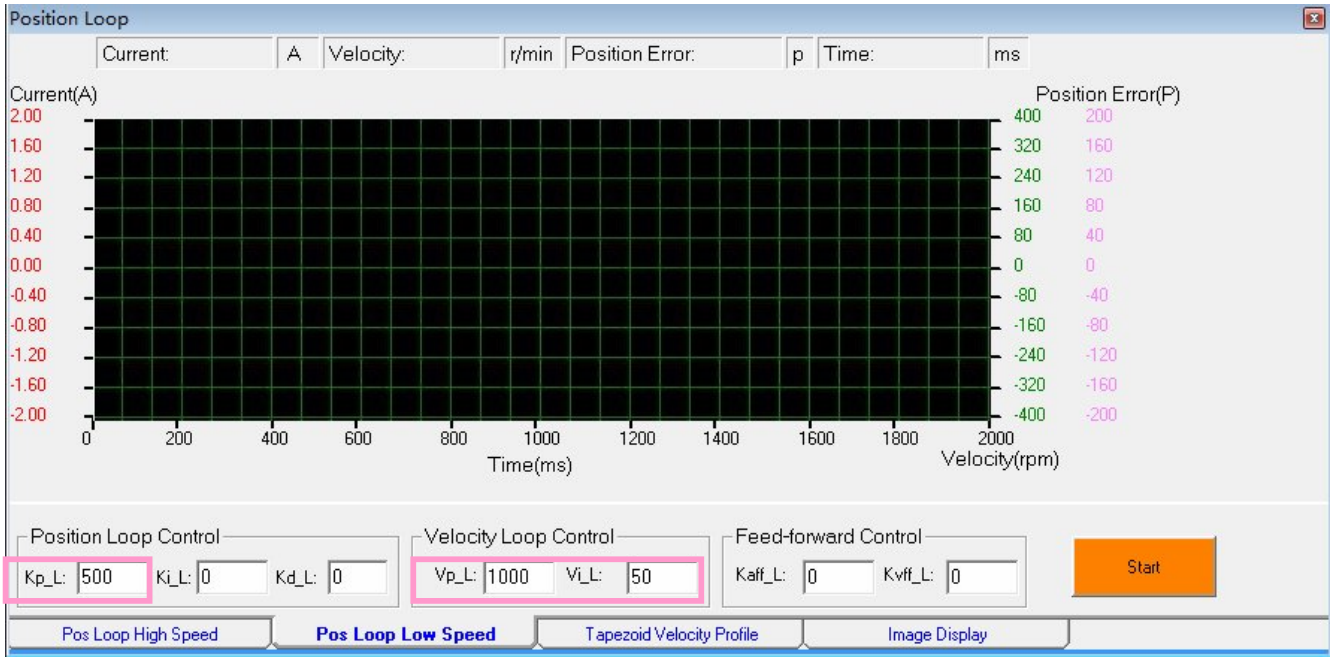
## *Low-Speed Gain Set VS. High-Speed Gain Set*

The ACS 2.0 series drive adopts two gain sets in order to solve the contradiction between fast system response and lower motor noise. The two gain sets are switched automatically according to the motion status. Generally speaking, the low speed gain set which locates in the "Pos Loop Low Speed" tab takes effect when the system goes into low-speed or standstill state. The high speed set which locates in the "Pos High Speed" tab takes effect when the motor starts a motion.

## *Step 4: Tune the low speed gain set when motor shaft is locked*

Click Tuning->Position Loop on the menu bar to open the position loop tuning window. Click the "Pos Loop Low Speed" tab to start the tuning. The most significant gains are Vp_L, Vi_L and Kp_L. You can set the Kvff_L, Kaff_L, Ki_L and Kd_L to zero.

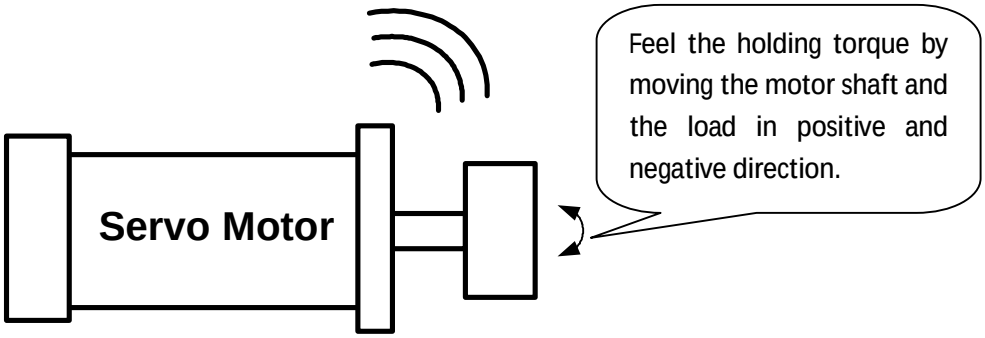
The most significant parameters for the low-speed gain set




The typical tuning procedure of the low speed gain set:

Step 4.1: Set small value of Vp_L, ViL and Kp_L. Assign Ki_L, Kd_L, Kaff_L and Kvff_L to zero. Here we set Vp_L = 1000, Vi_L = 50 and Kp_L = 500. The initial values of these significant parameters are depending on the motor, the supply voltage of the drive, the transportation system and the load inertia.

Step 4.2: Increase the Vp_L to increase the holding torque (stiffness) of the motor shaft (or load) until the motor noise or vibration can not be accepted. You can feel the holding torque by moving the motor shaft and the load in positive and negative direction.

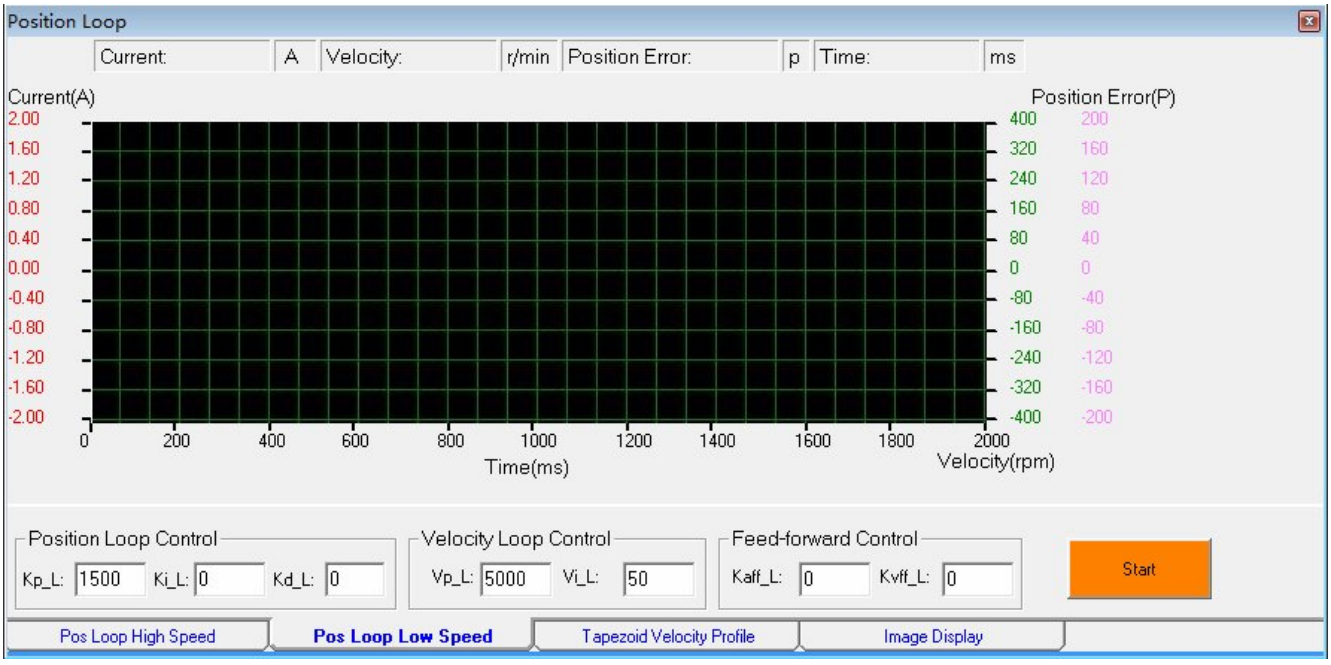



In this example, we get relatively good torque at Vp_L = 5000.

Step 4.3: Increase the Kp_L to improve the holding torque. You can follow the same way as increasing the Vp_L in step 4.2 to determine the suitable Kp_L for your system.

Step 4.4: Tuning of the low speed gain set is finished.

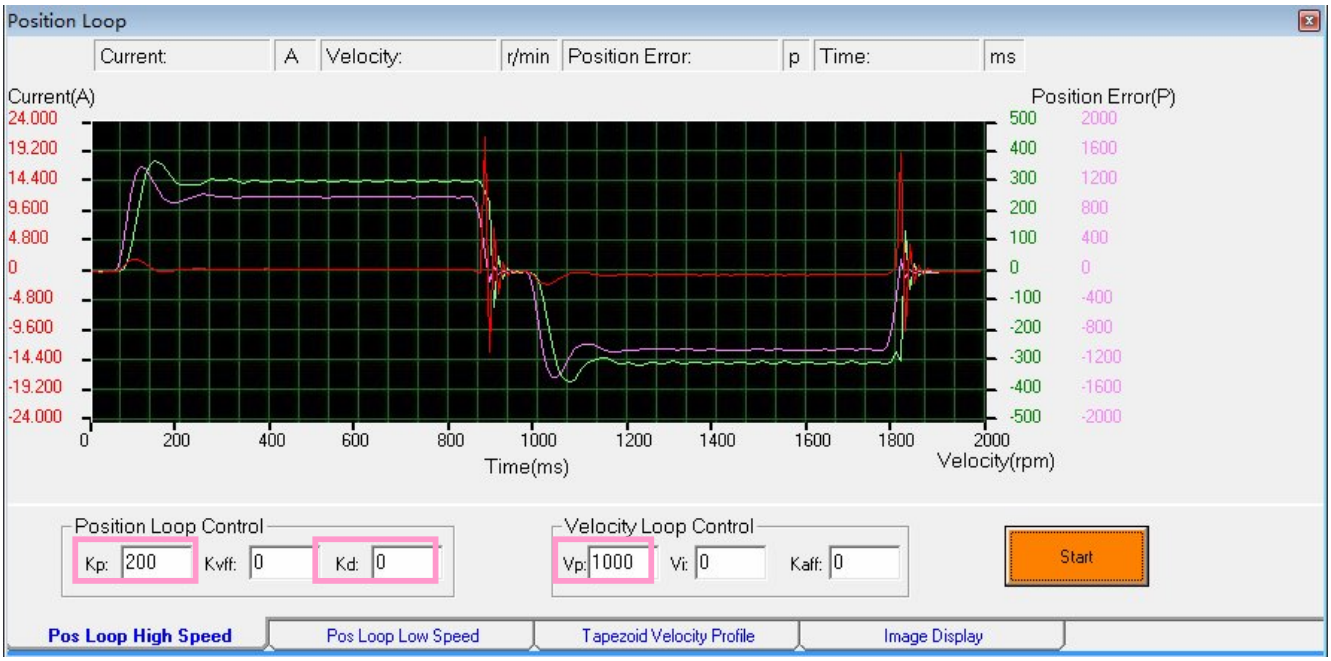
The values of the low-speed gain set after tuning in step 4




## *Step 5: Tune the high speed gain set and start the trapezoid motion*

Click the "Pos Loop High Speed" tab to start the tuning. The most significant gains are Vp, Kp and Kd. You can set the Kvff, Vi and Kaff to zero.

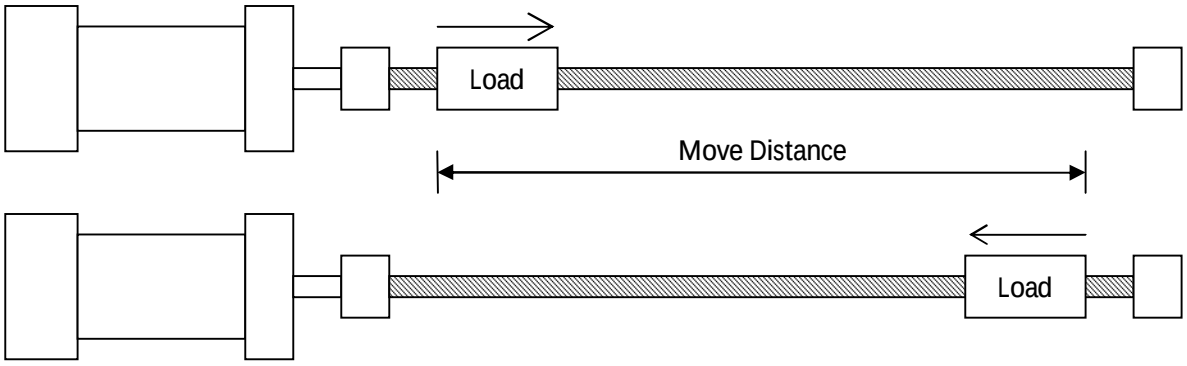
The most significant parameters for the high-speed gain set




The typical tuning procedure of the high speed gain set:

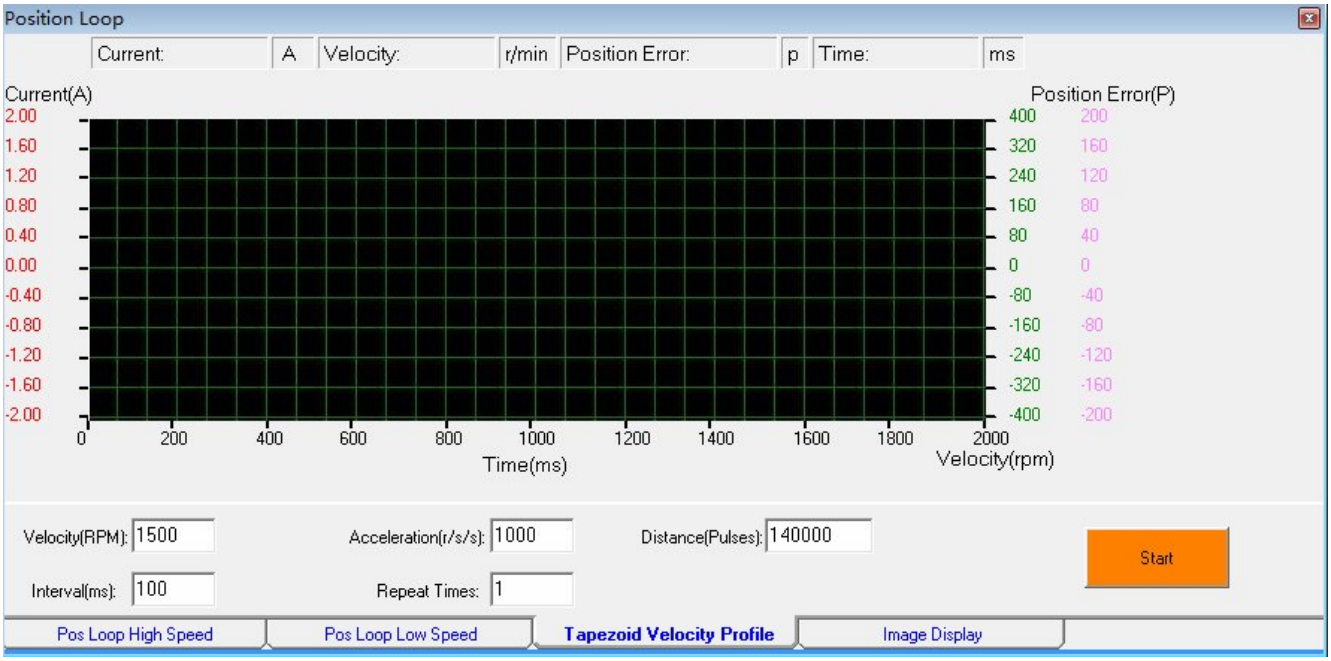
Step 5.1: Trapezoid Velocity Profile Setting and the Image Display Setting:


The tuning of high speed gain set requires the motor shaft (or load) to perform a forward and backward motion. Make sure initial motion direction is correct and the move distance will not exceed the traveling limit in both directions. If you are not sure about it, manual move the load to the center of the total travel and set low value for the velocity and move-distance. If the initial direction is converse, move the load the other side of the machine.



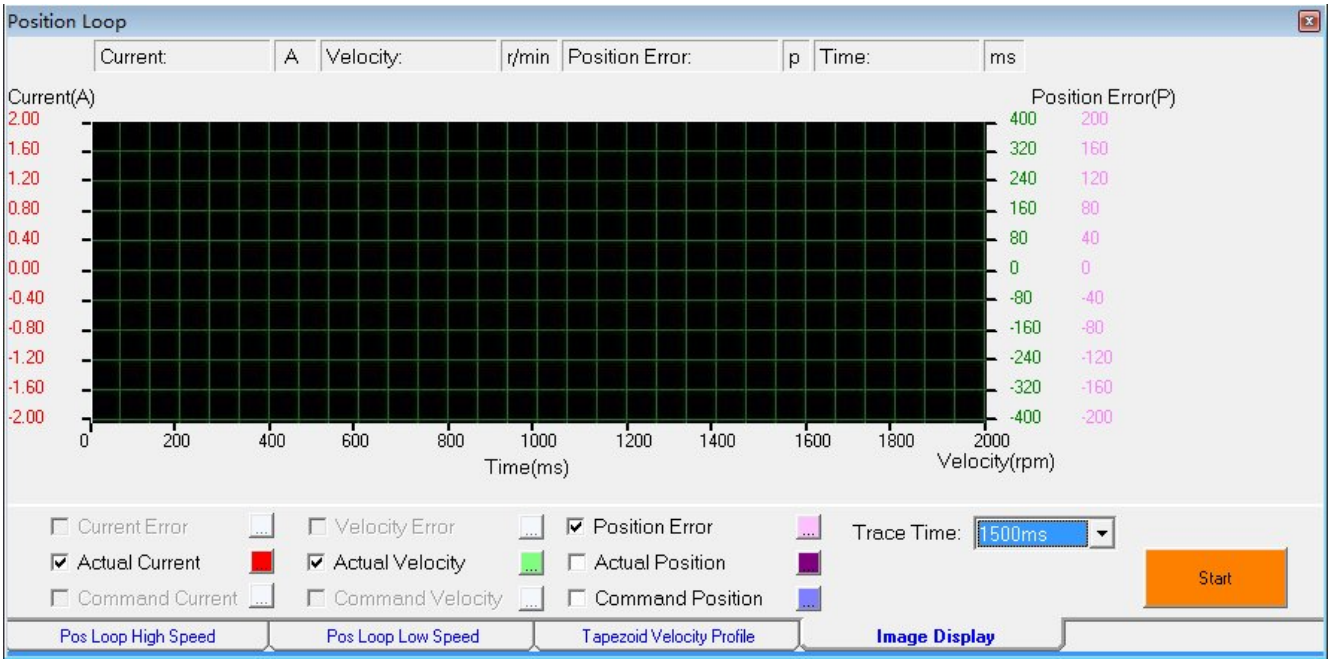

In this example, the trapezoid motion is defined as follows:
Velocity = 1500RPM, Acceleration = 1000 R/S/S
Distance = 140000, Interval = 100ms, Repeat Time = 1

The trapezoid velocity profile setting




Step 5.1 (continued): Check the "Actual Current", the "Actual Velocity" and the "Position Error" in the "Image Display" tab. The "Trace Time" is set to 1500ms.

The Image Display Setting

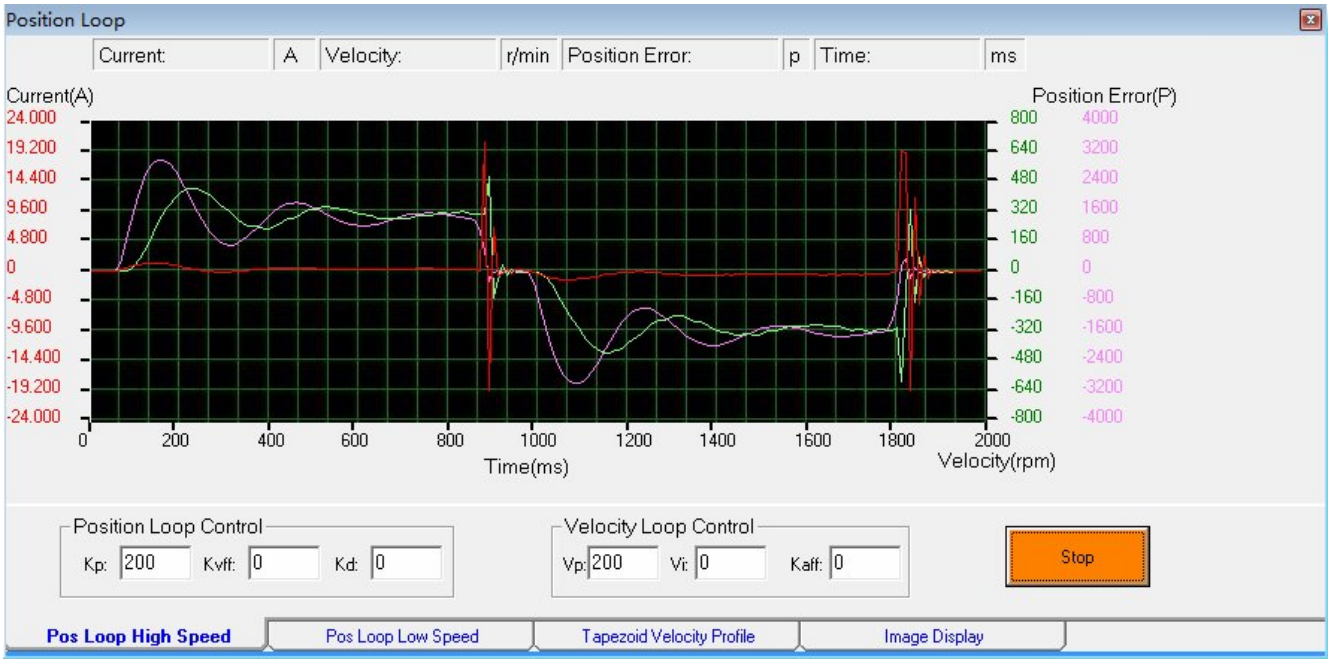


How to determine motion parameter and trace time for the tuning of your application?

| | |
|---|---|
| Velocity | The MAX operating speed of your application |
| Acceleration | The required acceleration for your application |
| Move distance | The max travel ( or the move distance) in the normal operation |
| Interval | 100ms or other value for a special test |
| Repeat time | 1 recommended |
| Trace Time | Adjust it to make the total trapezoid curve been displayed in the full window |

Step 5.2: Set small value for Vp and Kp. Let Kd equal to zero at first. Assign Kvff, Vi and Kaff to zero. Here we set Vp = 1000 and Kp = 200. The initial values of Vp and Kp are depending on the motor, the supply voltage of the drive, the transportation system and the load inertia. Big vibration may occur at acceleration stage due to low Vp, shown as the following figure.

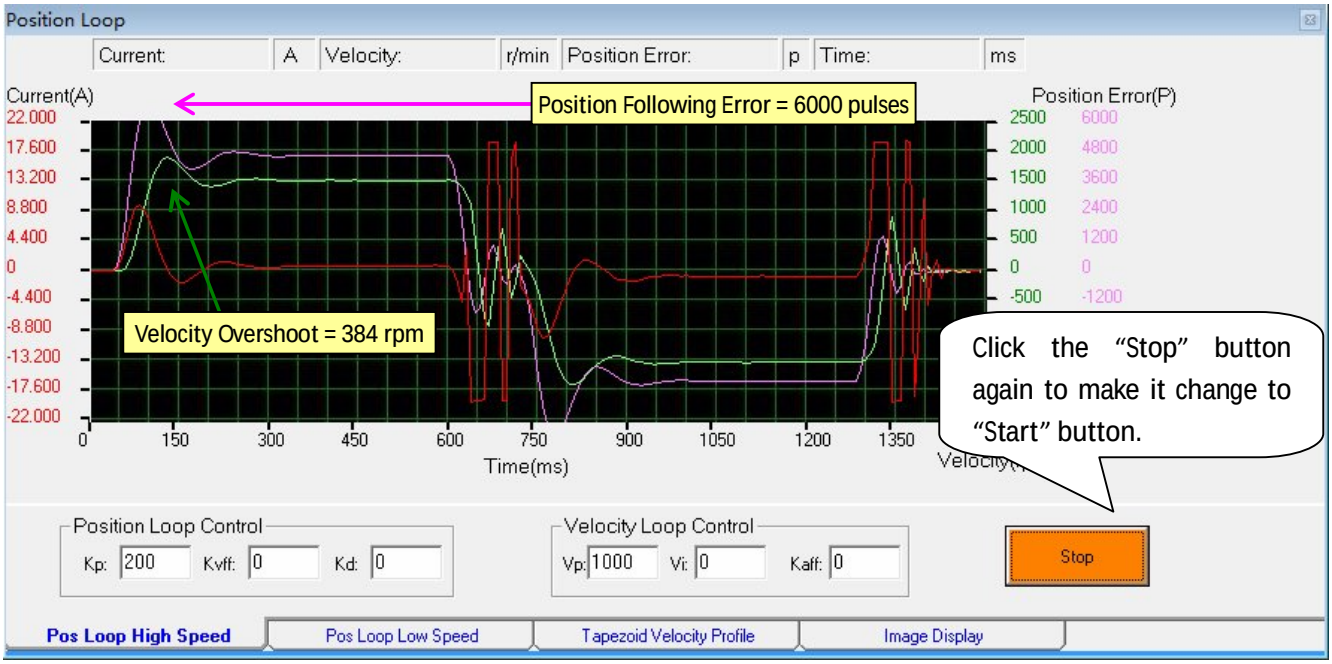
System vibration due to low Vp and Kp at the tuning of the high-speed gain set



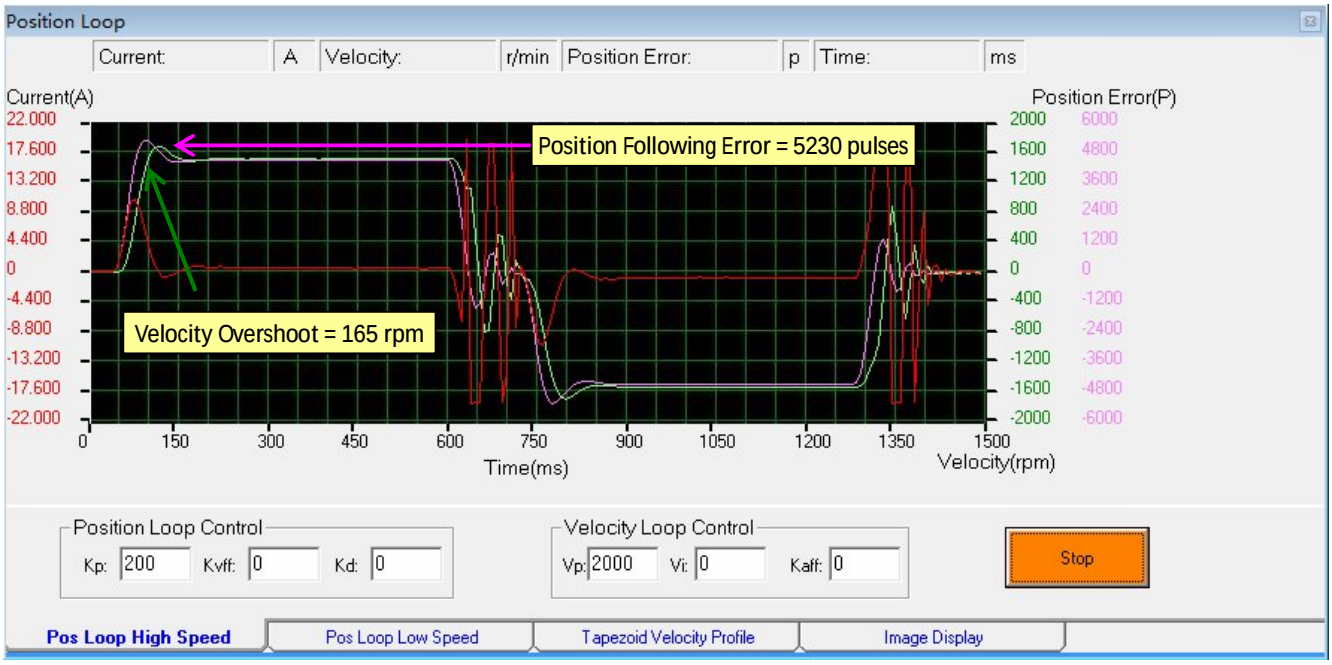

Step 5.3: Increase the value of the Vp to make the actual velocity curve (green one) rise as rapid as possible thus reducing the position following error. Click the "Start" button to issue a trapezoid motion. It may take several seconds for the plot window to update the motion curves. The curve of the actual velocity is closing to an ideal trapezoid curve with increasing Vp. The tuning process is shown as follows:

Step 5.3 (continued): Increase Vp

High Speed Gain Tuning: Kp = 200, Kd = 0, Vp = 1000

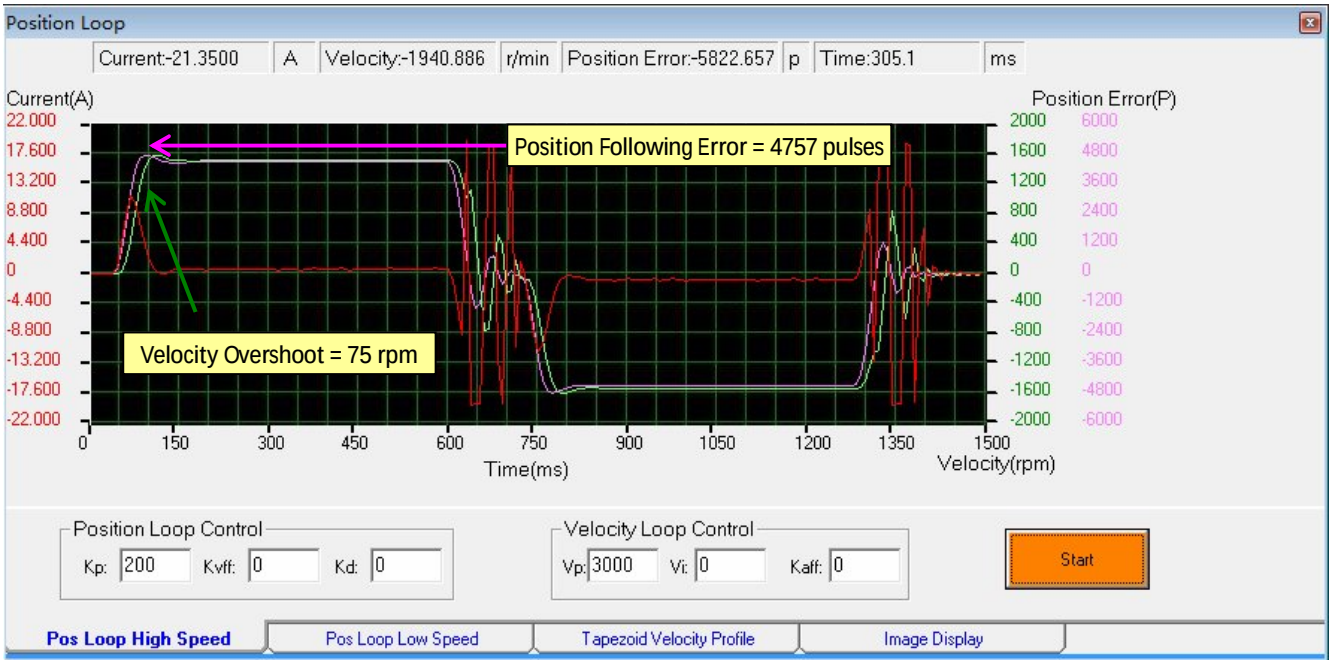



High Speed Gain Tuning: Kp = 200, Kd = 0, Vp = 2000

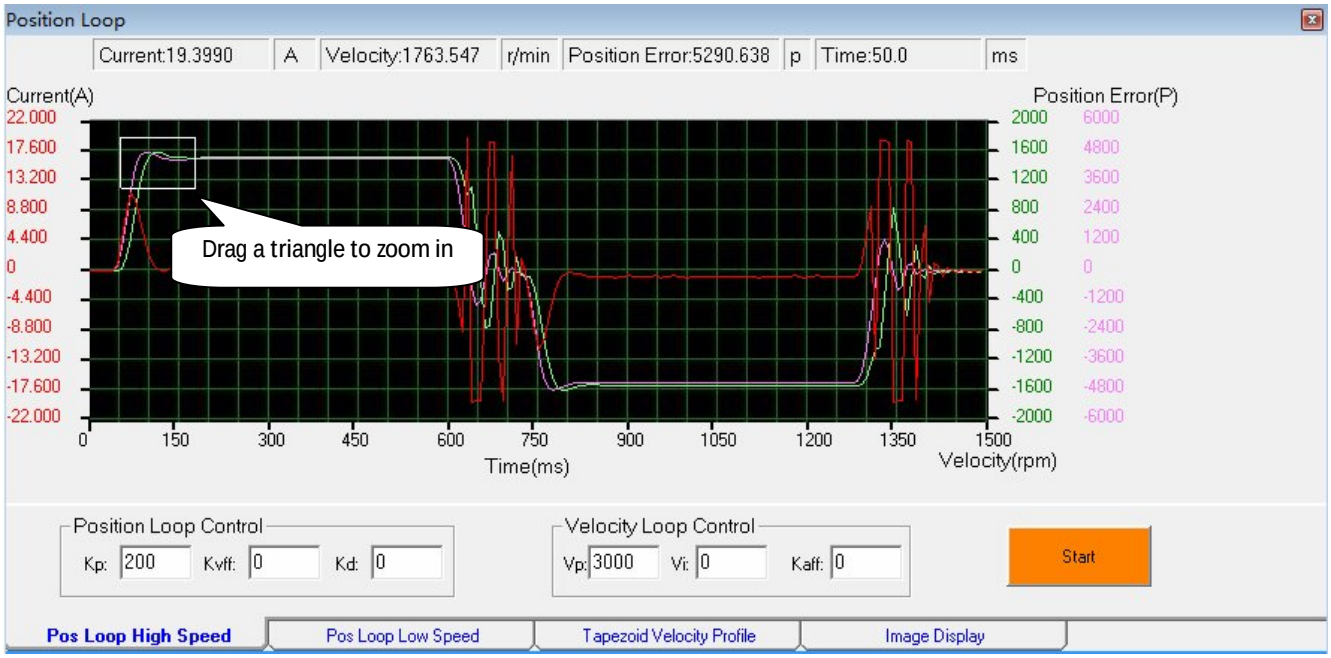


Step 5.3 (continued): Increase Vp

High Speed Gain Tuning: Kp = 200, Kd = 0, Vp = 3000

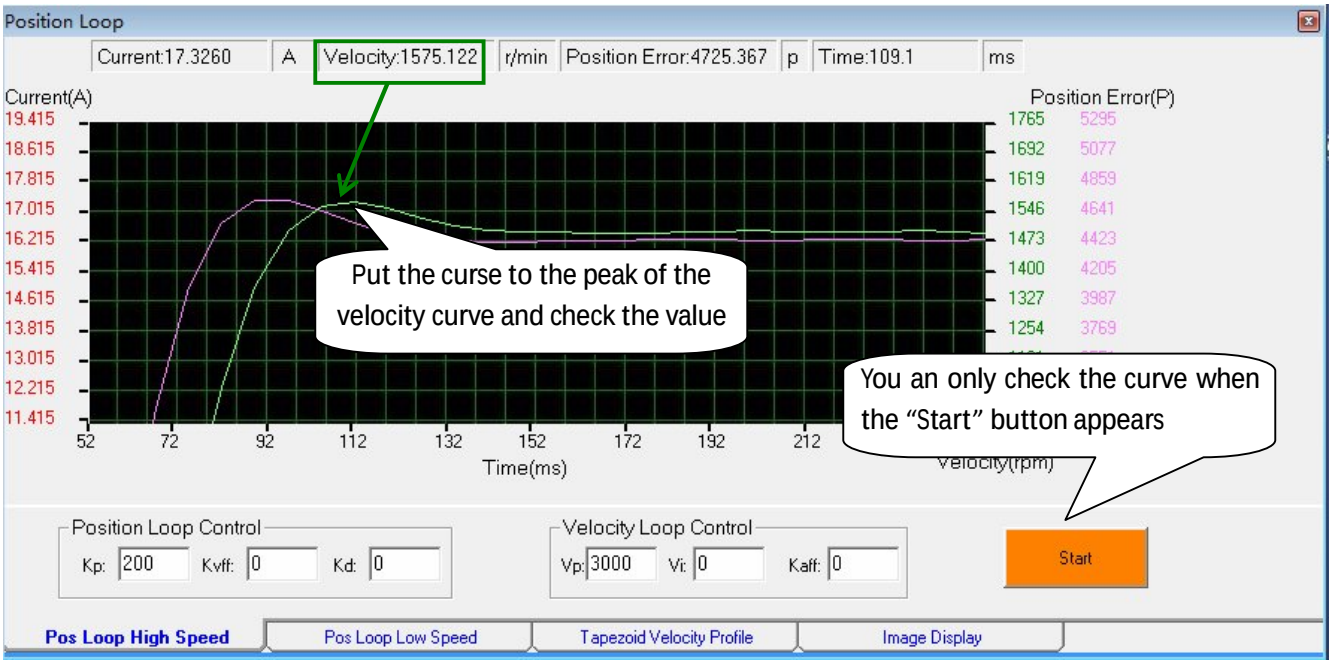



High Speed Gain Tuning: Drag a triangle to zoom in

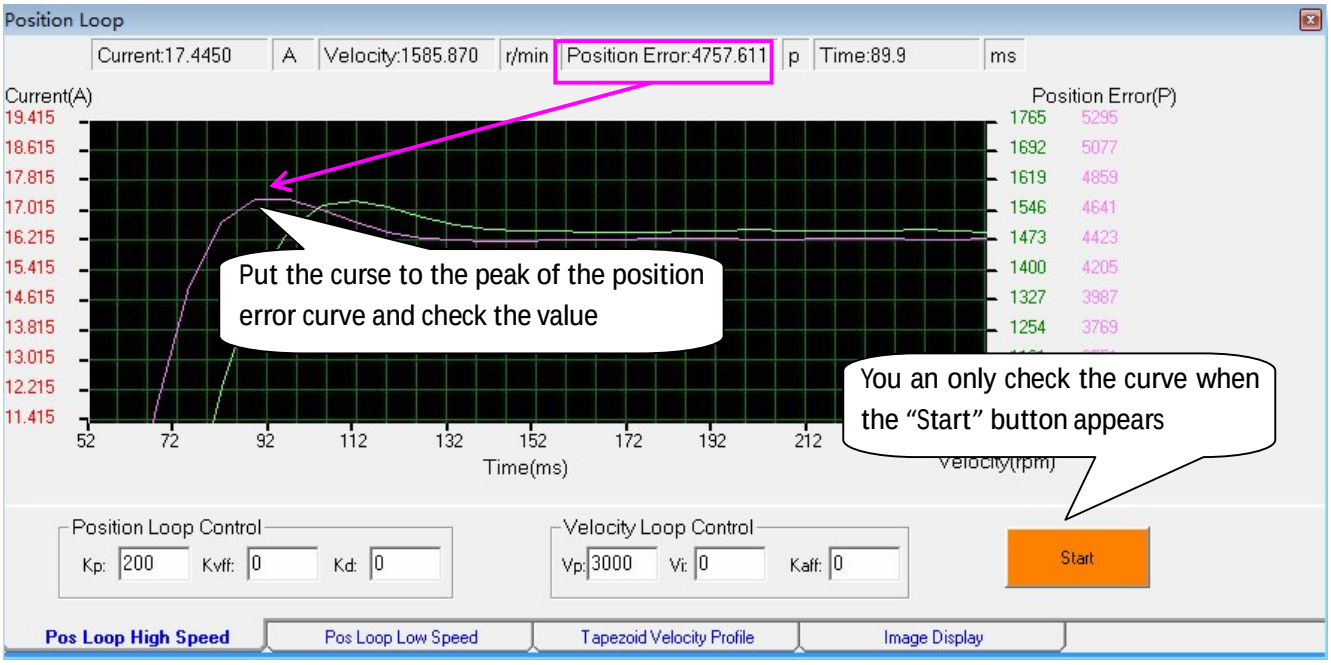


Step 5.3 (continued): Increase Vp

High Speed Gain Tuning: Check the peak value of the actual velocity

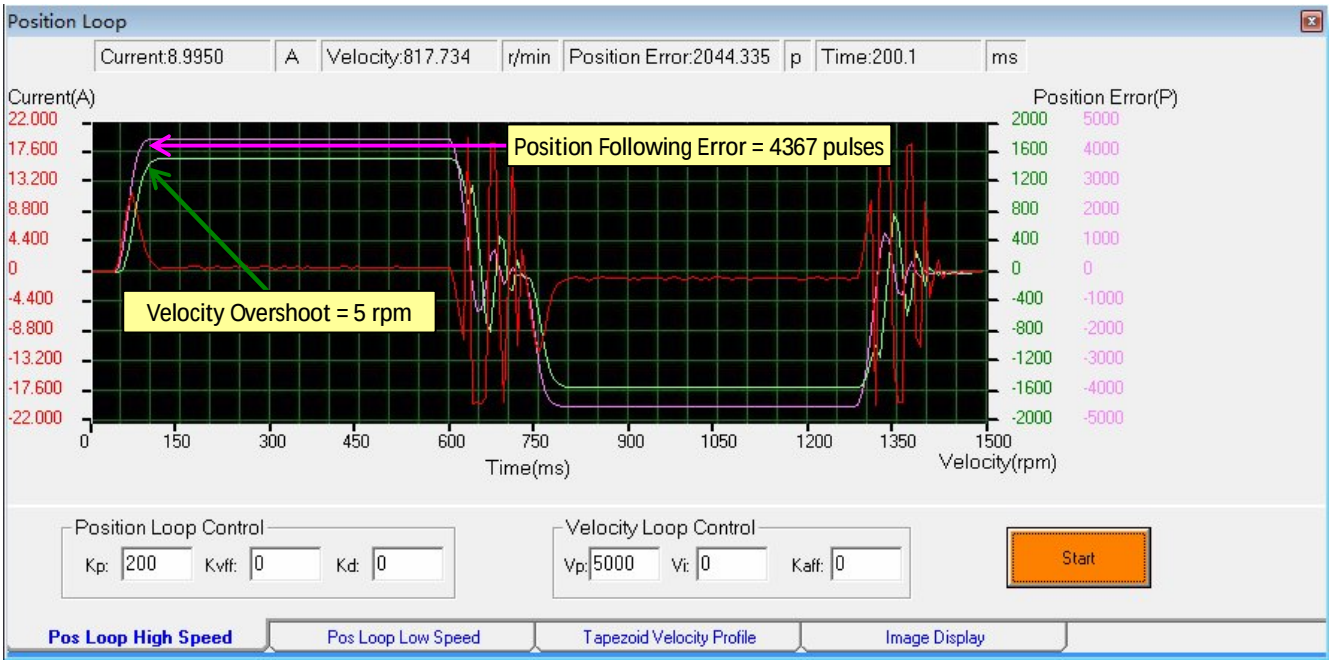



High Speed Gain Tuning: Check the peak value of the position following error



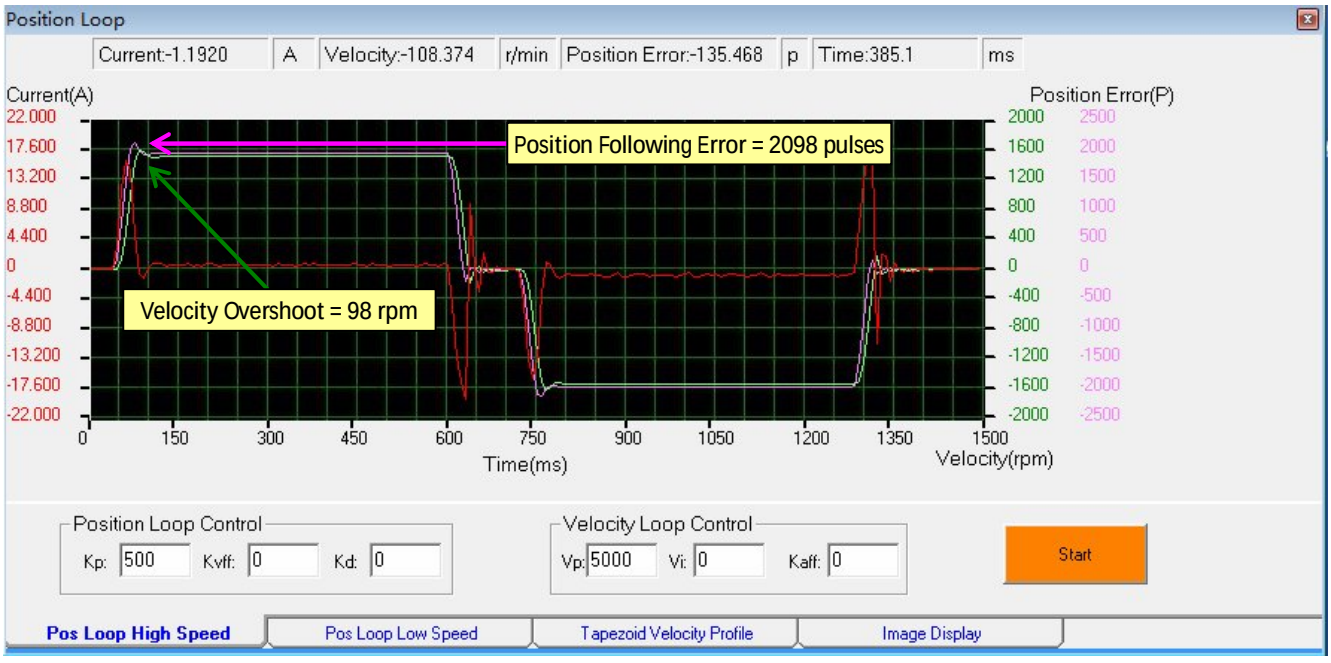
Step 5.3 (continued): Increase Vp

High Speed Gain Tuning: Kp = 200, Kd = 0, Vp = 5000



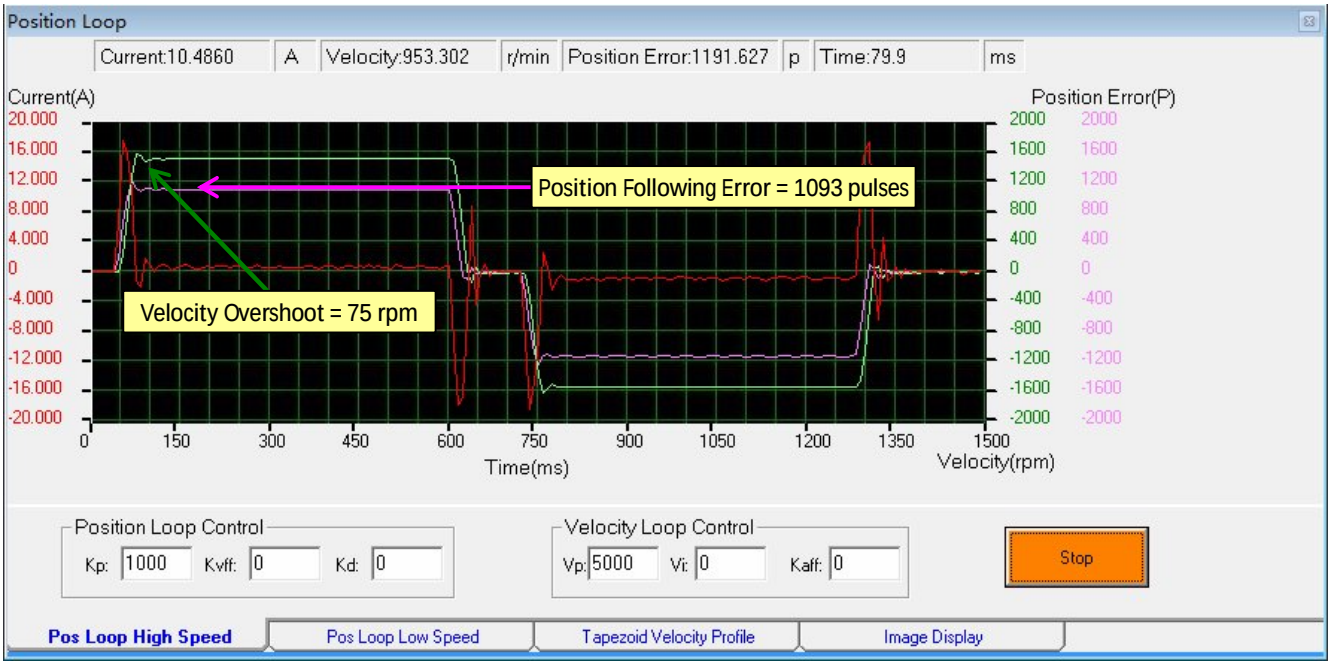

Step 5.4: Increase the Kp to reduce the position following error. You can follow the same way as increasing the Vp in step 4 to determine the suitable Kp value for your system.

High Speed Gain Tuning: Kp = 500, Kd = 0, Vp = 5000

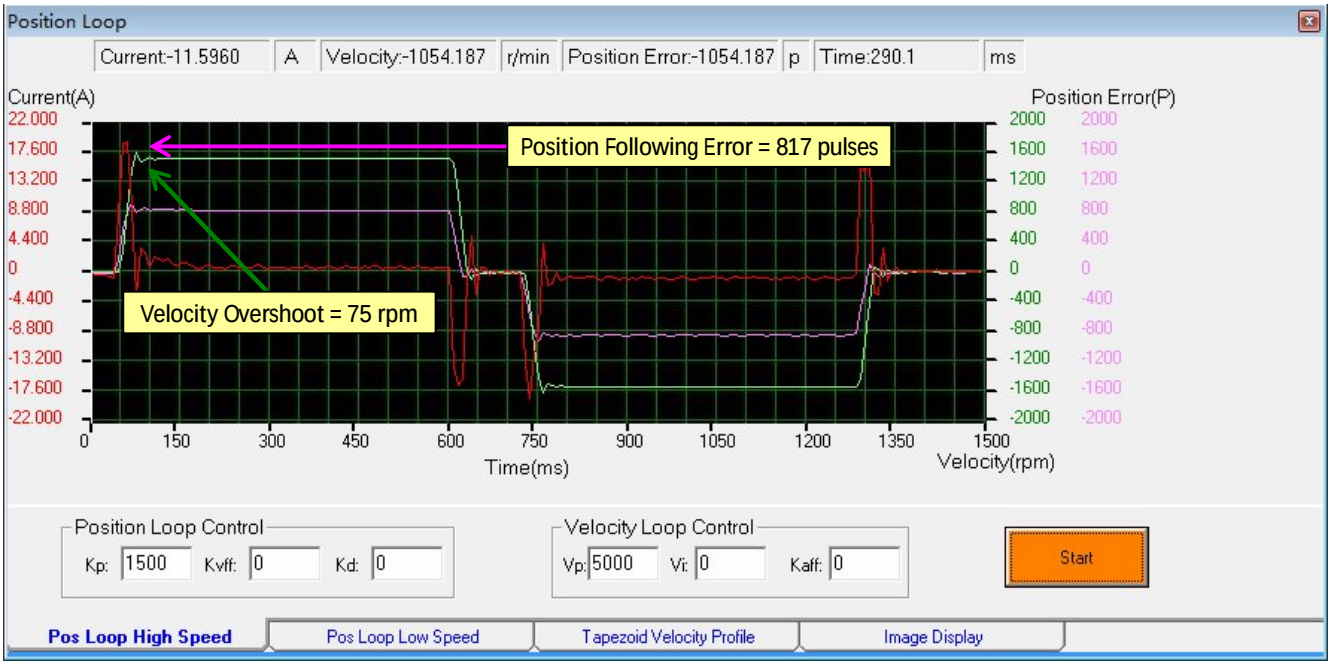


Step 5.3 (continued): Increase Kp

High Speed Gain Tuning: Kp = 1000, Kd = 0, Vp = 5000

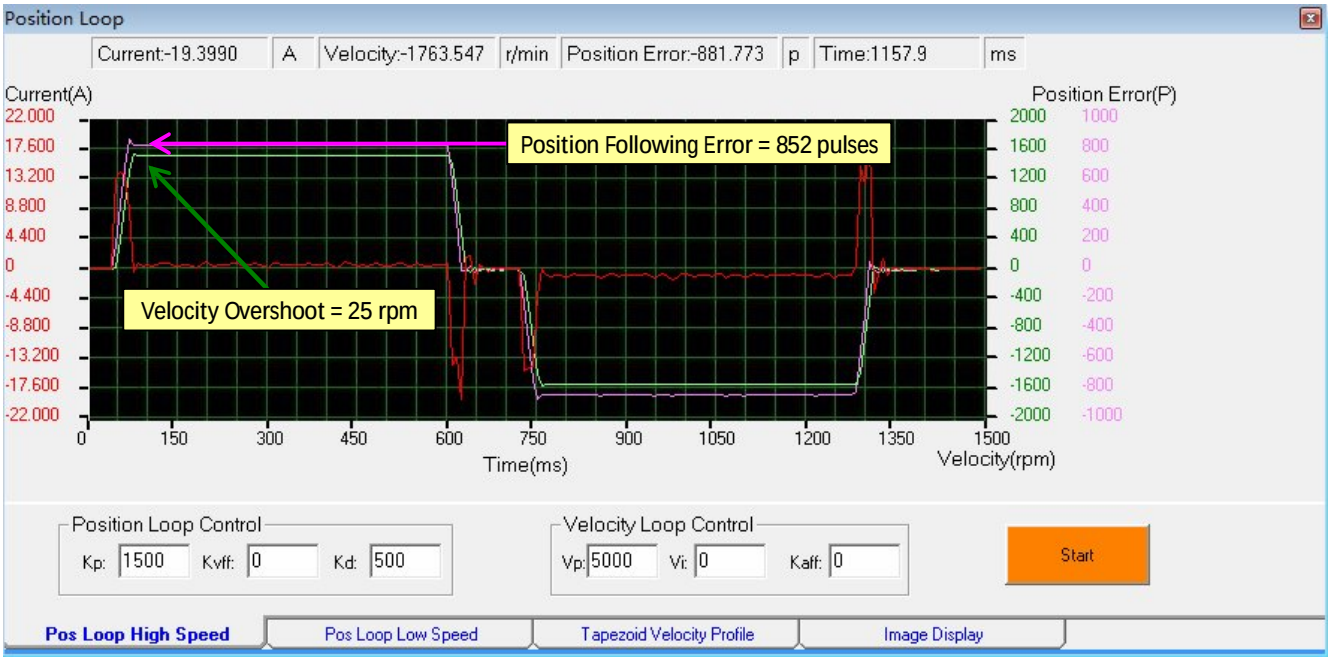



High Speed Gain Tuning: Kp = 1500, Kd = 0, Vp = 5000

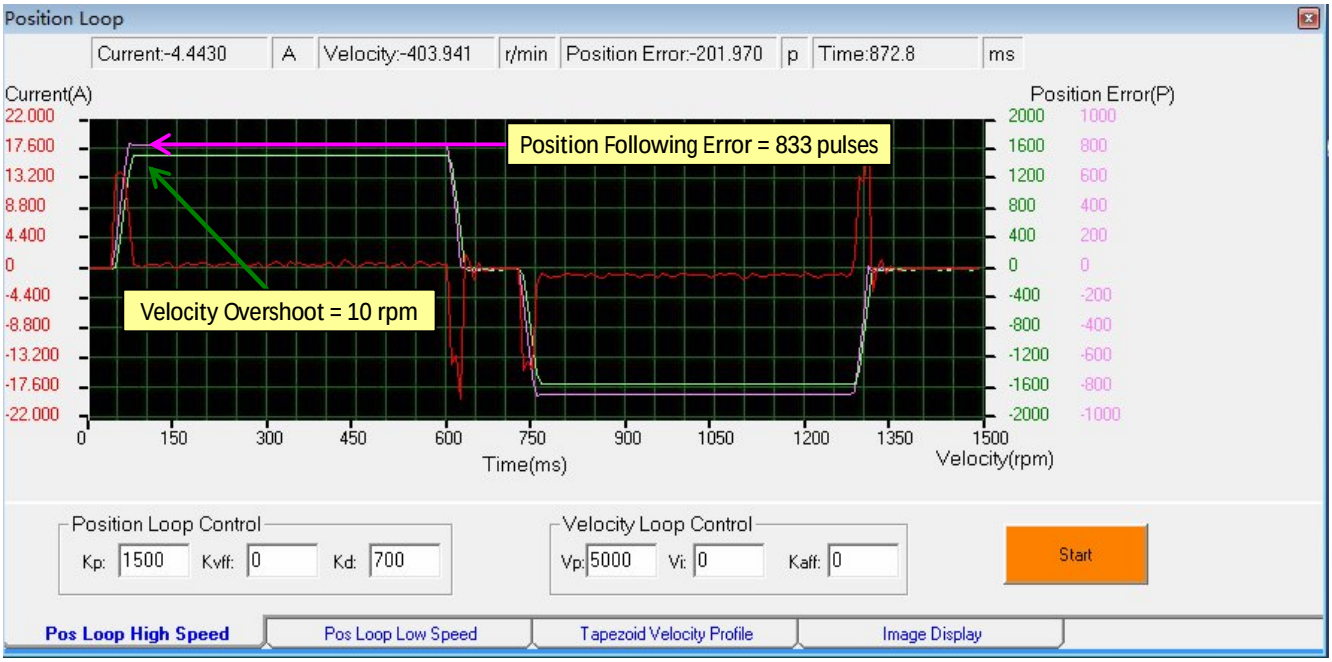


Step 5.5: Increase the value of Kd a little to suppress the velocity over shoot if necessary.

High Speed Gain Tuning: Kp = 1500, Kd = 500, Vp = 5000



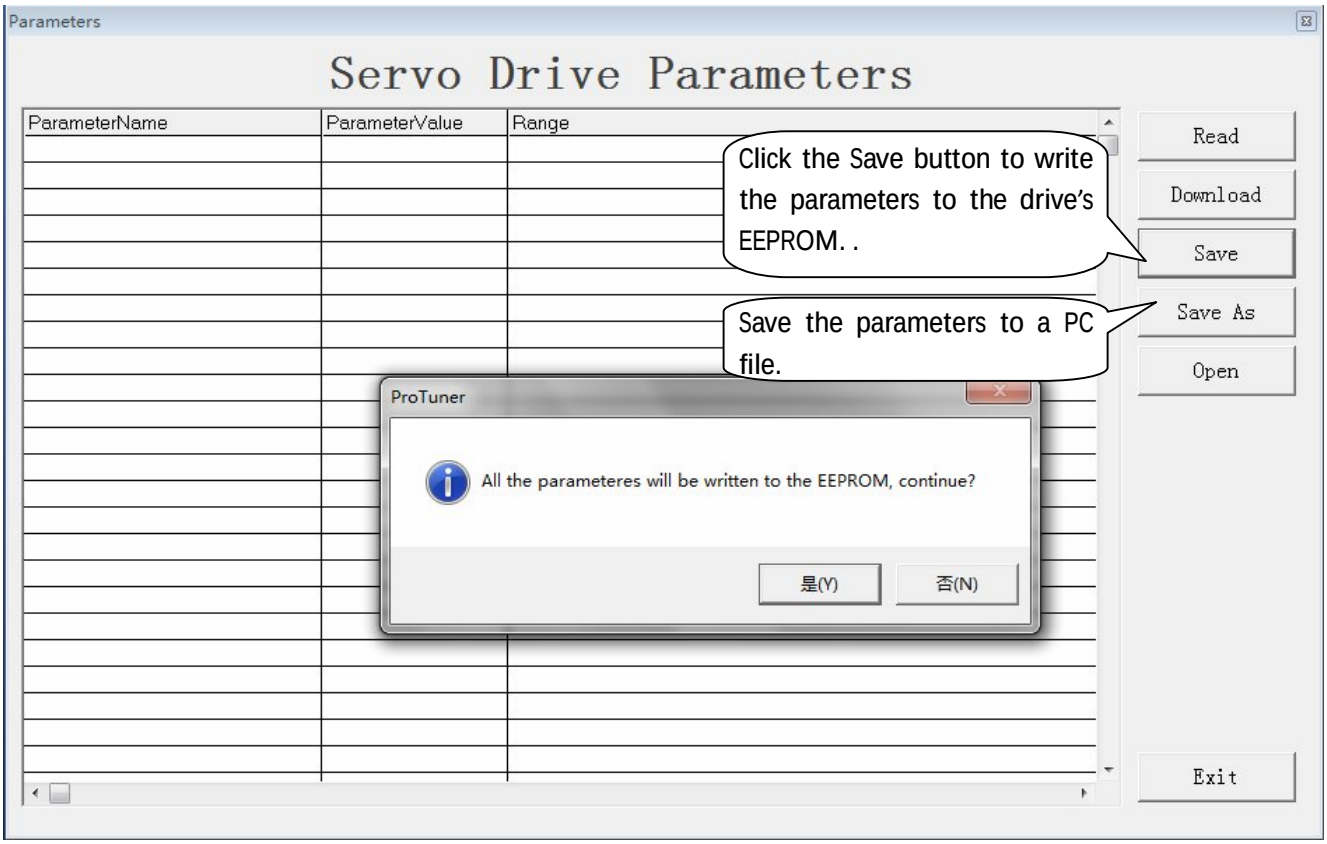

High Speed Gain Tuning: Kp = 1500, Kd = 700, Vp = 5000

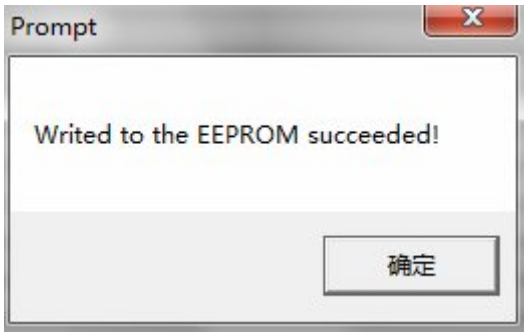



Step 5.6: Tuning of the high speed gain set is finished. You can continue to adjust the high speed gains if necessary.

## *Step 6: Save parameters to drive's NVM.*

All the parameters are just stored in the driver's RAM. Otherwise they will be lost after repowering the driver. Click Display->Show Parameters to open the "Parameters" window. Then click the Save button to write the parameters to the drive's EEPROM.



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