Software Operational Manual for ACS306

www.leadshine.com

SM-ACS306-R20110826

Change Log

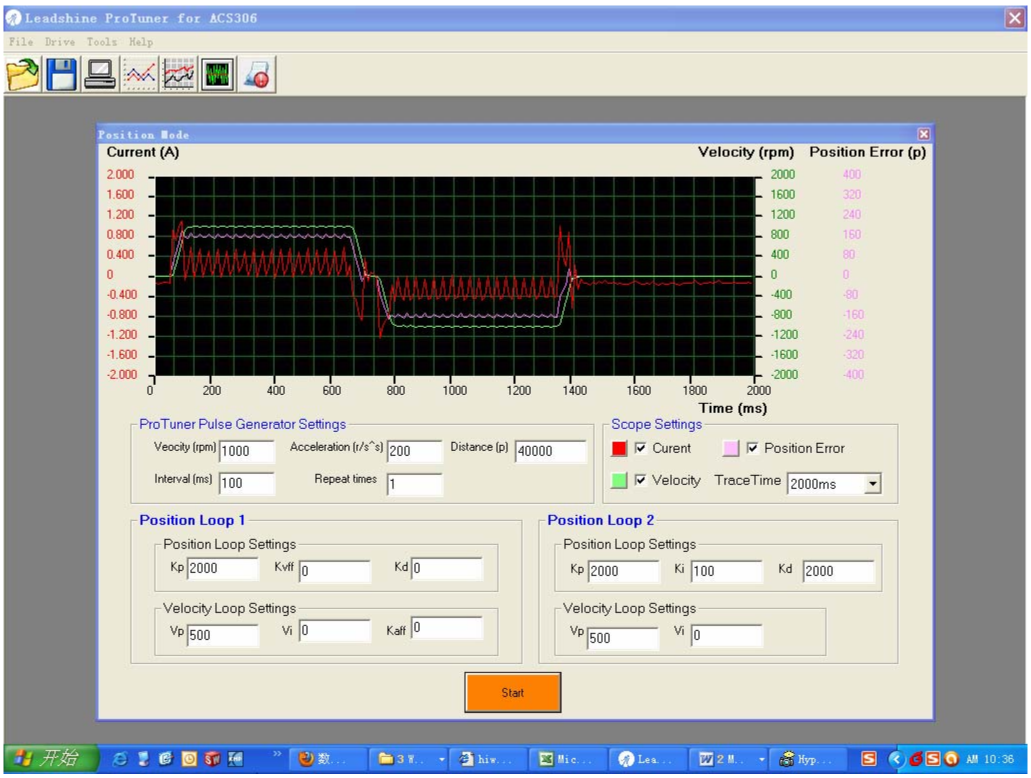
Revision Date	Changes	Version
2011-8-26	Original Create	SM-ACS306-R20110826

Table of Contents

Introduction

The ProTuner for ACS306 is a software tool designed to configure and tune the Leadshine digital servo drive ACS306. The user can tune the current loop and adjust the position loop parameters in this software.

Workspace



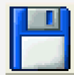
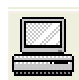
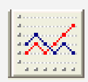
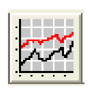
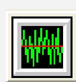
Menu

Toolbar

PID Tuning Window

Menus and Toolbar

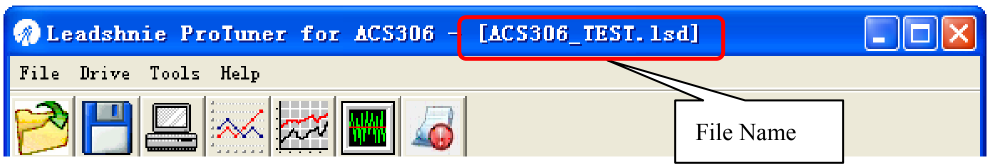
Menus and toolbars are at the top of the workspace. You can click menu bar to view the pull-down menu. The toolbar below the menu offers the most frequency used commands.

Menu	Pull Down	Toolbar	Function	Short cut
File ->	Open		Open a file	Ctrl + O
	Save		Save a file	Ctrl + S
	Save As	-	Save as a file	-
	Close	-	Close the current file	-
	Exit	-	Exit from the software	Ctrl + X
Drive ->	Connect	-	Connect to drive	Ctrl + N
	Properties		Set drive properties like I/O logic, motor parameters.	-
	Current Loop		Set current loop parameters Kp and Ki and test.	-
	Position Loop		Set position loop PID parameters and test.	-
	Download to Drive		Download all data to drive	-
	Reset Drive		Restore factory setting	-
Tools->	Scope		Open the scope and check the measured current, position following error and motor velocity.	-
	Error Log		Check the error log.	-
Help->	User Manual on Web		Hardware manual	-
	Software Manual on Web		Software manual	
	About Leadshine ProTuner		Software information	-

Using the Software

Opening a file

If you want to reload the configuration data from a file in the PC, click on the File->Open. The parameters in the software's workspace will be updated. The file name will appear on the right of the tile bar.



Save a file

Click Drive->Save to save the data of current workspace to the opened file. If there is no a file opened, the Save dialog box appears and you can type in the file name.

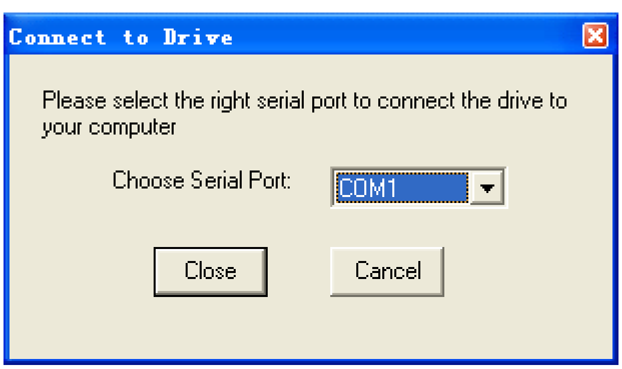
Save as a file

Click Drive->Save As to save the data in current workspace to a file and rename it.

Close

Click Drive->Close to close the current file.

Connecting Drive



Connect to Drive window appears when you open the software. You can open it by clicking Drive->Connect any time. Select the right serial port and click on the Open button. The software will try to connect to the drive and read the settings. It may take several minutes. Please wait.

Before clicking on the Open button, please make sure:

1) The RS232 cable .has been connected between the drive and the PC's serial port.
2) The drive has been powered on and the green LED is turned on.

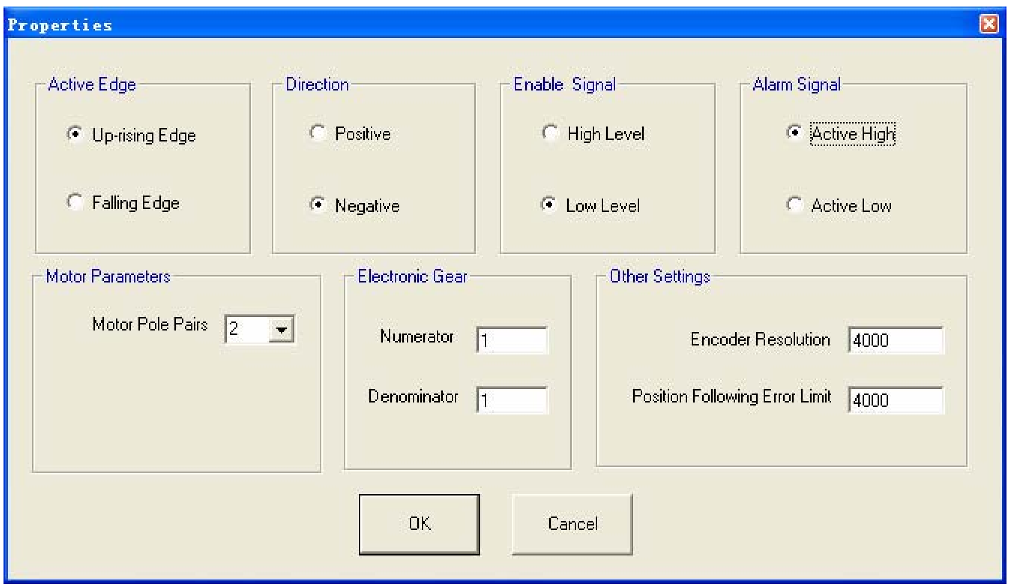
The motor is unnecessary connecting to the drive if you just want to change the parameters but not tuning.

Notice

Do not connect or disconnect serial cable when the drive is powered on. The drive's communication circuit may be damaged.

Caution

Property Window



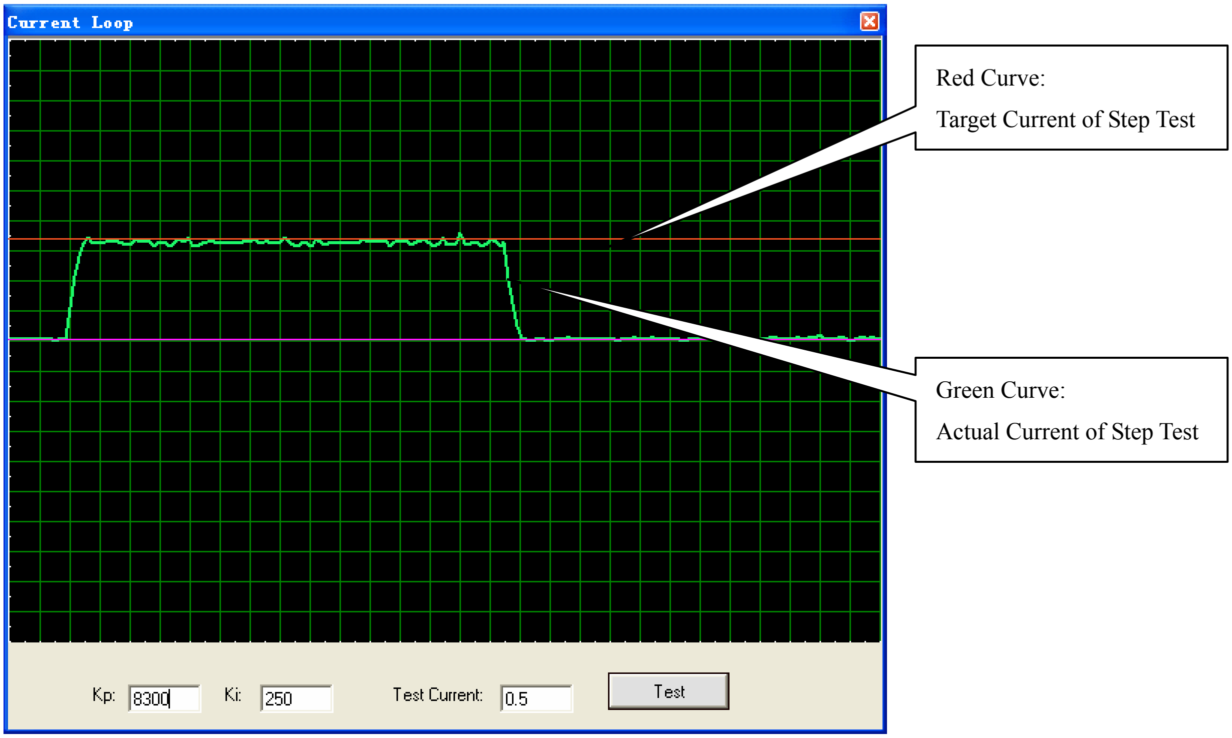
Click Drive->Properties to open the Properties window. The user can set the command's active edge, direction logic, active level of the Enable and Alarm signal, position following error, electronic gear and motor pole pairs according the motor and application.

Notice

The Motor Pole Pairs is very important parameter. .It is 2 for Leadshine's BLM series motor and 4 for Leadshine's ACM series motor.

Item	Description	Range
Active Edge	Setting the triggered edge of pulse command signal.	Up-rising / Falling
Direction	Setting Default motor rotate direction. Note: The default direction is also related to motor coil connections.	Positive / Negative
Enable Signal	Setting active level of Enable signal.	High Level/ Low Level
Alarm Signal	Setting active level of Enable signal.	High / Low
Encoder Resolution	Encoder Resolution for the Internal Pulse Generator. Note: This parameter is only used for the Internal Pulse Generator. **It is 4 times of the encoder lines.**	400 – 60000
Position Following Error Limit	The limit of the difference between commanded position and the actual measured position. When position following error exceeds the Position Following Error Limit in the drive, the following error protection will be activated.	0 – 65535
Electronic Gear	This parameter includes numerator and denominator. You can scale the pulse frequency and calculate the motor speed as follows: $RPM = \frac{(Pulse\ \ Input\ \ Frequence) \times 60}{(Encoder\ \ Resolution) \times 4} \times \frac{Numerator}{Denominator}$	1/255 – 512/1
Motor Pole Paris	Motor poles divided by 2. Please refer to motor datasheet.	1 – 20

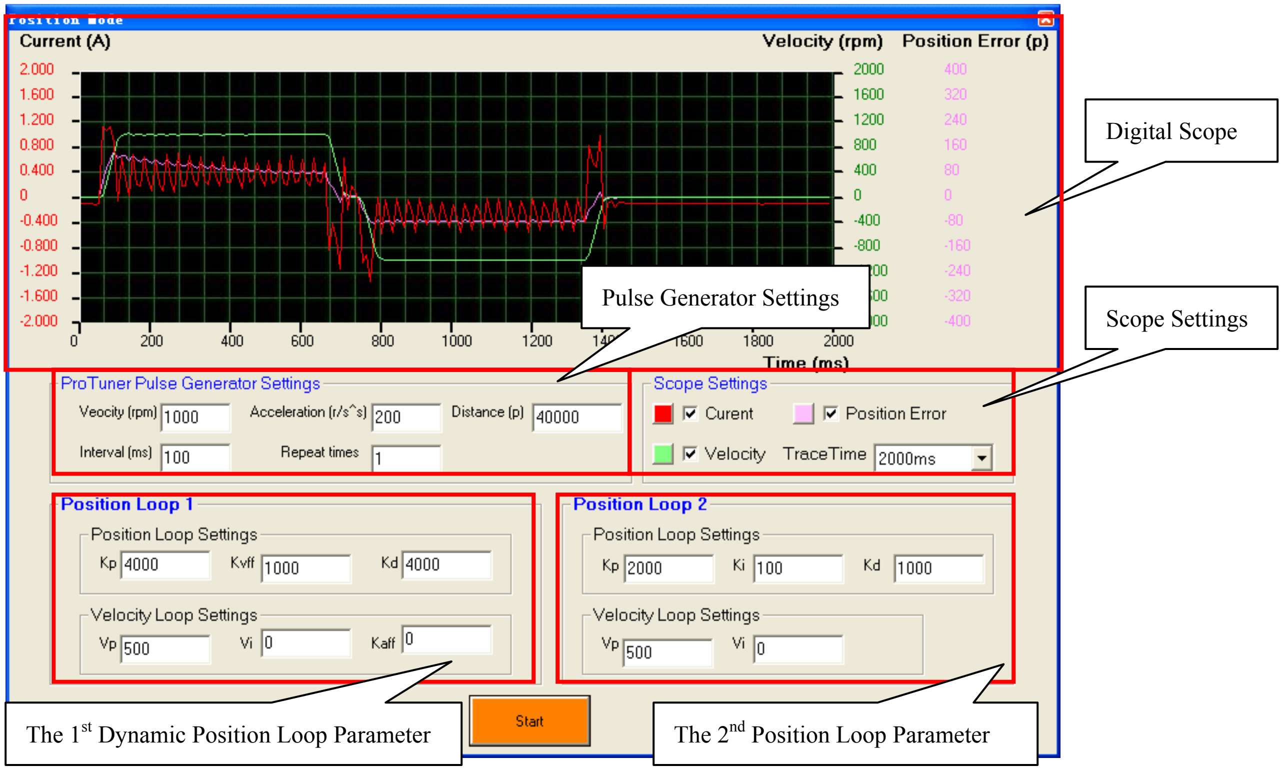
Current Loop Tuning Window



Click Drive->Current Loop to open the current loop tuning window. It is used to configure current loop parameters according to different motor. In the tuning window, the user can adjust the proportional gain, integral gain and test Current.

Item	Description	Range
Proportional Gain	Increase this parameter to make current rise fast. Proportional Gain determines the response of the drive to current setting command. Low Proportional Gain provides a stable system (doesn't oscillate), has low stiffness, and large current error, causing poor performances in tracking current setting command in each step. Too large Proportional Gain values will cause oscillations and unstable systems.	1 – 65535
Integral Gain	Adjust this parameter to reduce the steady error. Integral Gain helps the drive to overcome static current errors. A low or zero value for the Integral Gain may have current errors at rest. Increasing the Integral Gain can reduce the error. If the Integral Gain is too large, the systems may "hunt" (oscillate) about the desired position.	1 – 65535
Test Current	The current amplitude for the step response.	0.5 – 6 A
Test Button	Click this button to activate the test. A target curve (red) and an actual curve (green) will be displayed on the screen for user analysis.	-

Position Loop Tuning Window



Click Drive->Position Loop to open the position loop tuning window. The user can adjust the position loop PID parameters and see the result by clicking the Start button. A build-in Pulse Generator performs trapezoid velocity motion and the Digital Scope displays the motor's actual velocity, current and position following error.

Digital Scope

Item	Description	Range
Current (A)	Current axis of the digital scope. Unit: Amp.	-
Velocity (rpm)	Velocity axis of the digital scope. Unit: rpm	-
Position Error (p)	Axis of Position following error in digital scope. Unit: Pulse	-

ProTuner Pulse Generator Settings

Item	Description	Range
Velocity (rpm)	Target velocity of Pulse Generator.	1– 65535 rpm
Acceleration (r/s^2)	Acceleration of Pulse Generator.	1 – 65536 r/s^2
Distance (s)	Move distance of Pulse Generator.	1 – 65536 pulses
Interval	Interval between the positive and negative move.	1 – 65535 ms
Repeat Times	Repeat times.	1– 65535

Scope Settings

Item	Description	Range
Current	Actual measured current. Click to display it in the scope.	-
Position Error	Position following error. The difference between commanded position and the actual measured position.	-
Velocity	Actual measured velocity measured by the encoder. Ideally, this value should be as close as possible to the commanded velocity.	-
Trace Time	Trace time of the digital scope.	100 – 3000ms

The 1st Position Loop Parameters

When the motor speed is > APPROX. 500RPM, the 1st position loop parameters take effect immediately for the motor behavior.

Note: The 2nd position loop parameters will be used when the motor speed is < APPROX. 10 RPM. If the motor speed is between 10 to 500 RPM, the control parameter will switch to the 2nd position loop smoothly.

Item	Description	Range
Kp	**Position Proportional Gain**. Proportional Gain determines the response of the system to position errors. Low Proportional Gain provides a stable system (doesn't oscillate), has low stiffness, and large position errors under load. Too large Proportional Gain values will cause oscillations and unstable systems.	0 – 65536
Kvff	**Velocity feed-forward gain**. Velocity feed-forward speeds up the system response.	0 – 65536
Kd	**Position Derivative Gain**. Derivative Gain provides damping by adjusting the output value as a function of the rate of change of error. A low value provides very little damping, which may cause overshoot after a step change in position. Large values have slower step response but may allow higher Proportional Gain to be used without oscillation.	0 – 65536
Vp	**Velocity Proportional Gain.** Vp has similar effect as Kp but it is in the velocity loop**.**	0 – 65536
Vi	**Velocity Integral Gain**. It can be used to reduce the steady error of velocity when the velocity is settled.	0 – 65536
Kaff	**Position Acceleration feed-forward gain**. It is used to reduce the position following error during acceleration and deceleration.	0 – 65536

The 2nd Position Loop Parameters

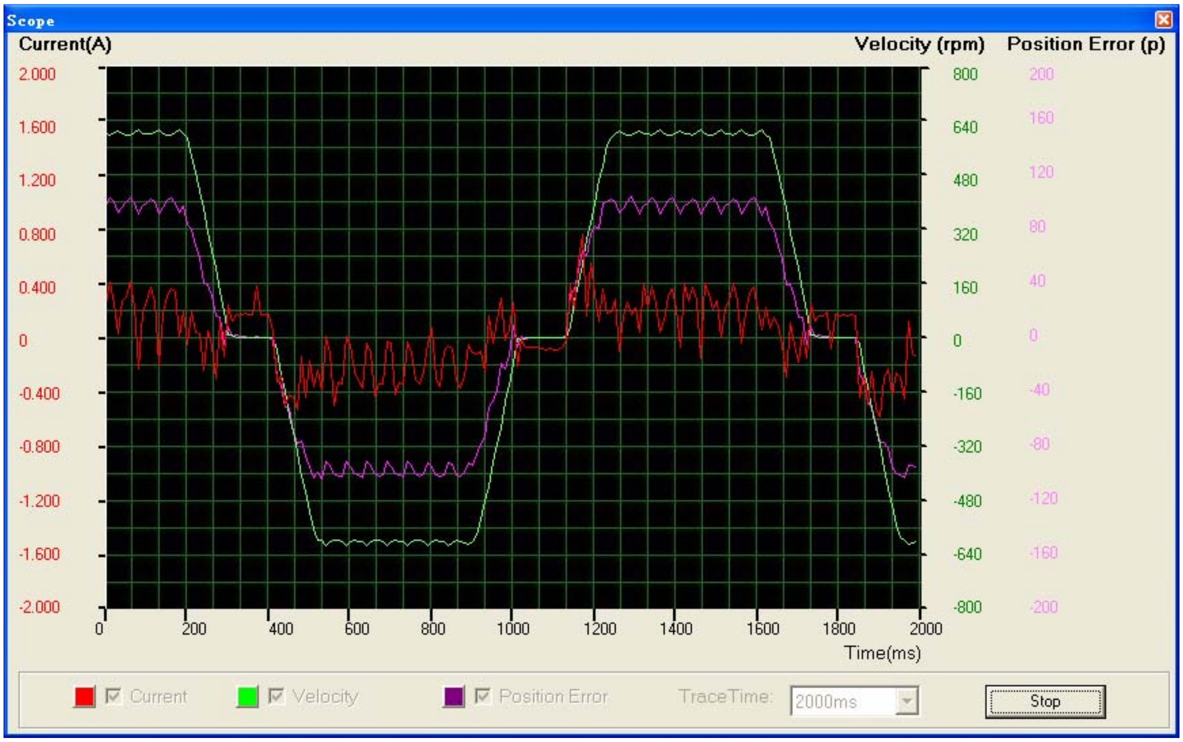
When the motor speed is< APPROX 10 RPM, the 2nd position loop parameters take effect immediately for the motor behavior.

Note: The 1st position loop parameters will be used when the motor speed is > APPROX. 500 RPM. If the motor speed is between 10 to 500 RPM, the control parameter will switch to the 1st position loop smoothly.

Item	Description	Range
Kp	**Position Proportional Gain**. Proportional Gain determines the response of the system to position errors. Low Proportional Gain provides a stable system (doesn't oscillate), has low stiffness, and large position errors under load. Too large Proportional Gain values will cause oscillations and unstable systems.	0 – 65536
Ki	**Integral Gain**. Integral Gain helps the control system overcome static position errors caused by friction or loading. The integrator increases the output value as a function of the position error summation over time. A low or zero value for the Integral Gain may have position errors at rest (that depend on the static or frictional loads and the Proportional Gain). Increasing the Integral Gain can reduce these errors. If the Integral Gain is too large, the systems may "hunt" (oscillate at low frequency) about the desired position.	0 – 65536
Kd	**Position Derivative Gain**. Derivative Gain provides damping by adjusting the output value as a function of the rate of change of error. A low value provides very little damping, which may cause overshoot after a step change in position. Large values have slower step response but may allow higher Proportional Gain to be used without oscillation.	0 – 65536
Vp	**Velocity Proportional Gain.** Vp has similar effect as Kp but it is in the velocity loop**.**	0 – 65536
Vi	**Velocity Integral Gain**. It is used to adjust the steady velocity error when the velocity is stable.	0 – 65536

Scope

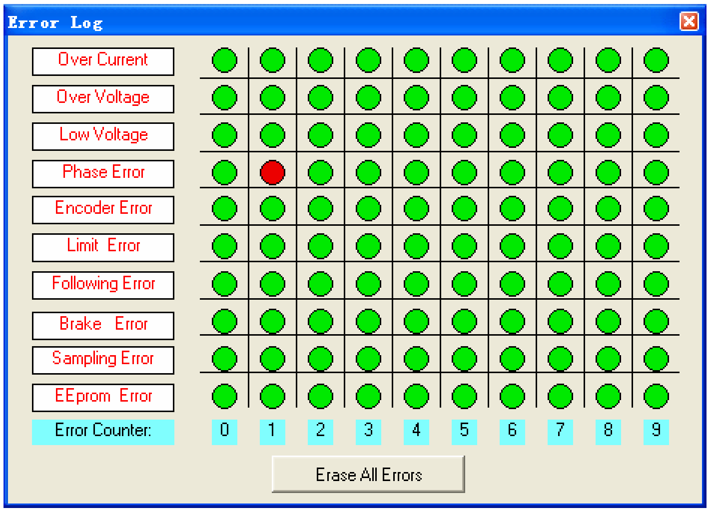
Click **Tool->Scope** to open the scope which is built inside the drive. You can check the actual measured velocity, current and position following error in this window.



Item	Description	Range
Current (A)	Current axis of the digital scope. Unit: Amp.	-
Velocity (rpm)	Velocity axis of the digital scope. Unit: rpm	-
Position Error (p)	Axis of Position following error in digital scope. Unit: Pulse	-
Current	Actual measured current. Click to display it in the scope.	-
Position Error	Position following error. The difference between commanded position and the actual measured position.	-
Velocity	Actual measured velocity measured by the encoder. Ideally, this value should be as close as possible to the commanded velocity.	-
Trace Time	Trace time of the digital scope.	100 – 3000ms
Start/Sop button	Click to turn on/off the scope.	-

Error Log Window

Click **Tool->Error Log** to open the error log window. This window shows both the present status of each error event and their history.



Item	Description
Over Current	Protection will be activated when the motor current is over 20A.
Over Voltage	Protection will be activated when the input voltage is over 40+/-1V.
Low Voltage	N/A.
Phase Error	N/A.
Encoder Error	Protection will be activated when no encoder feedback signals or wrong encoder/hall sensor feedback signals connected to the ACS306.
Limit Error	N/A.
Following Error	Protection will be activated when position following error exceeds the **Position Following Error Limit**.
Brake Error	N/A.
Sampling Error	N/A.
EEprom Error	N/A.
Error Counter	Display the No. of the errors.
Erase All Errors	Clear the error log.

Configuring the Drive

If it is the first time setup, you can follow the steps below to configure the drive.

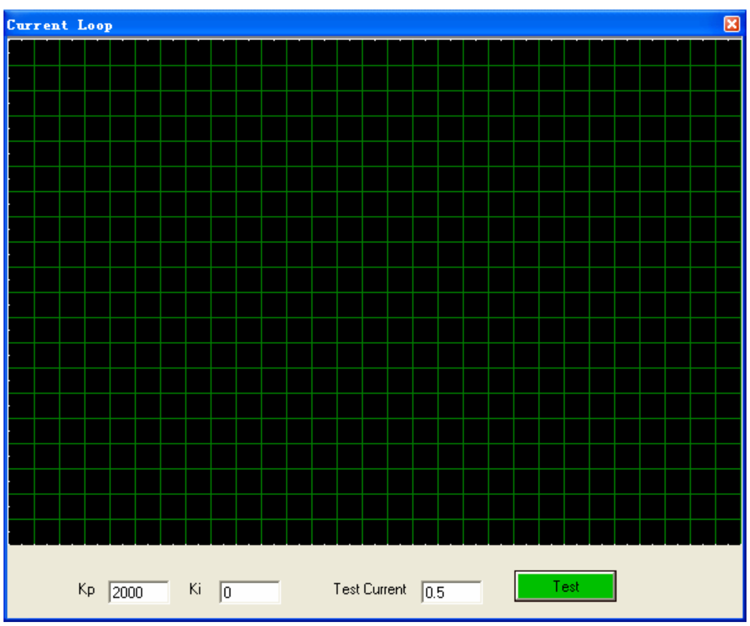
1) Set motor related parameters such as motor pole pairs, encoder resolution and position following error.
2) Tune the current loop parameters according to motor.
3) Tune the 1st position loop parameters for the high-speed performance.
4) Tune the 2nd position loop parameters for the low-speed performance.
5) Save the changes to drive's nonvolatile memory.

Notice The motor must be connected to the drive before trying to configure the drive.

Current Loop Tuning

The ACS306's current loop need to be tuned before normal operation in order to get optimize responses with different motors. Otherwise the motor will be easily stall or howls when power-up. Below is the tuning process for a NEMA 23 motor with 24VDC supply voltage.

Step 1: Click **Drive->Current** Loop to open the tuning window. Set **Test Current** 1 and start the tuning with small **Kp** and "zero" **Ki**. Here we set **Kp** 2000.

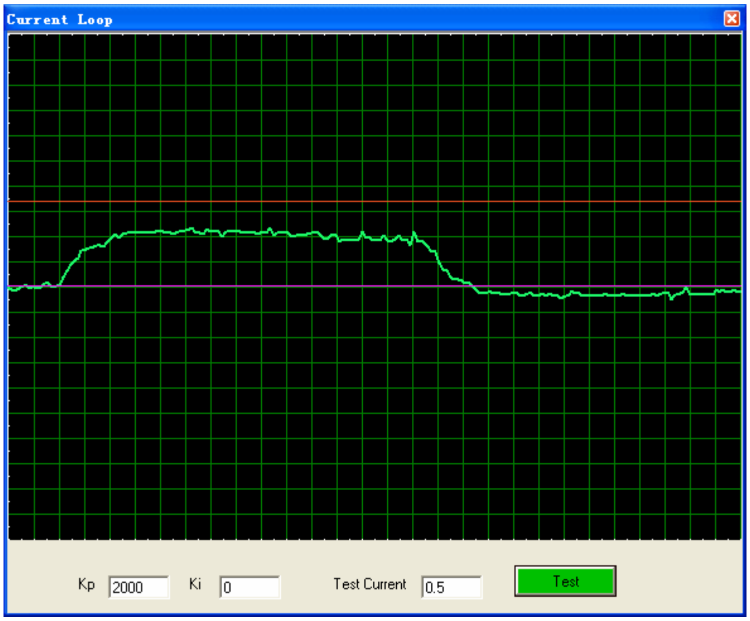


Initial Value

Kp = 2000

Ki =0

Step 2: Click the **Test** button and the plot window will show two curves. The red one is target current and the green one is actual current. There is large gap between them in the scope. It indicates that a large **Kp** needs to be introduced.

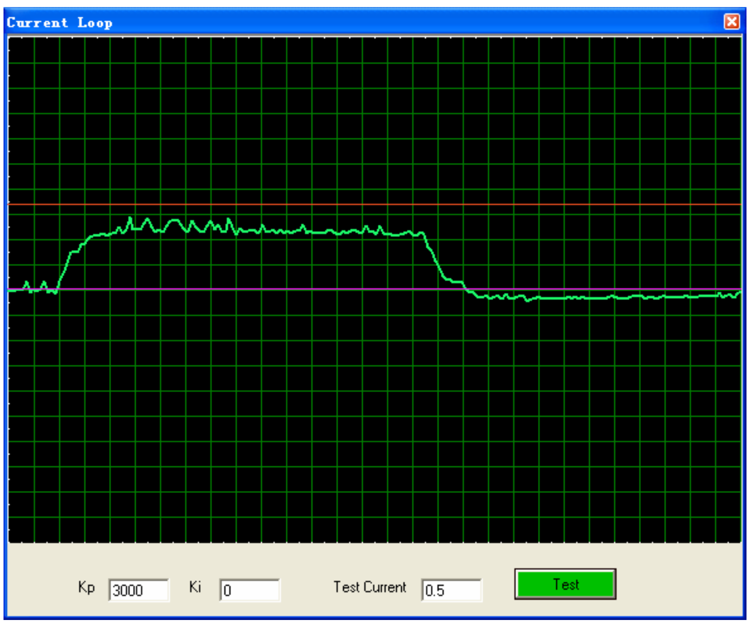


Start Test:

Proportional Gain = 2000

Integral Gain = 0

Step 3: Increase **Kp** to 3000 and click **Test.** The distance between target value and actual value is smaller but a higher **Kp** is still needed.

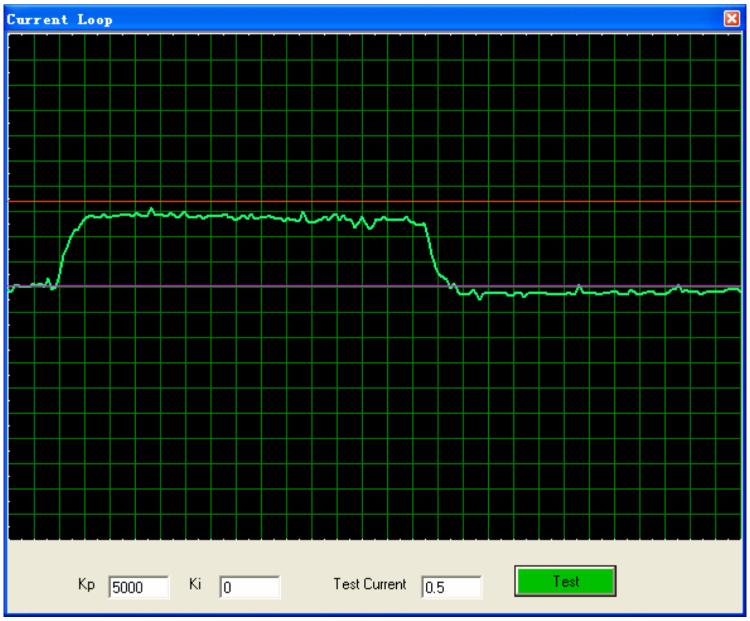


↑ Proportional Gain:

Kp = 3000

Ki = 0

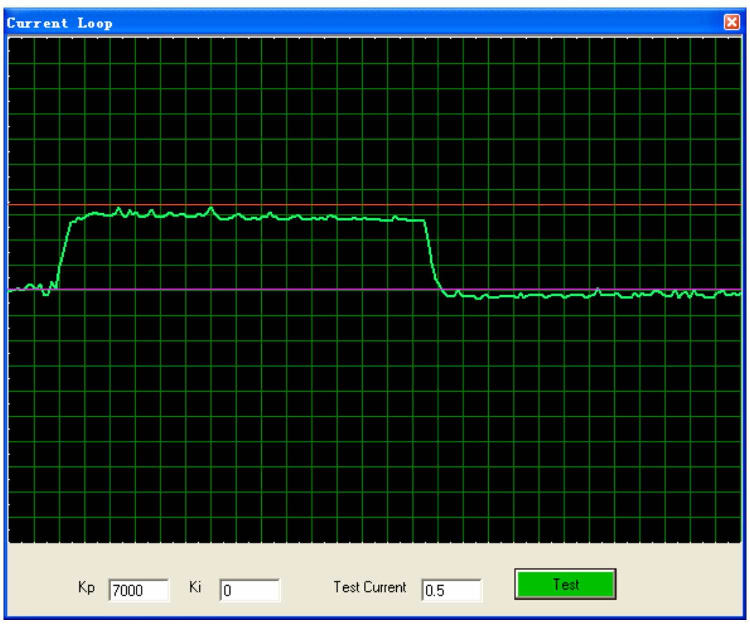
Step 3: Give **Kp** 5000, 7000, 9000 and click the **Test** button**,** respectively. The green curve is getting more and more close to the red curve. Intersection appears when we increase **Kp** to 6000. It indicates that you need to stop increasing Kp and back off. Our purpose is to make the green curve (the actual current) close to the red curve (the target).



↑ Proportional Gain:

Kp =5000

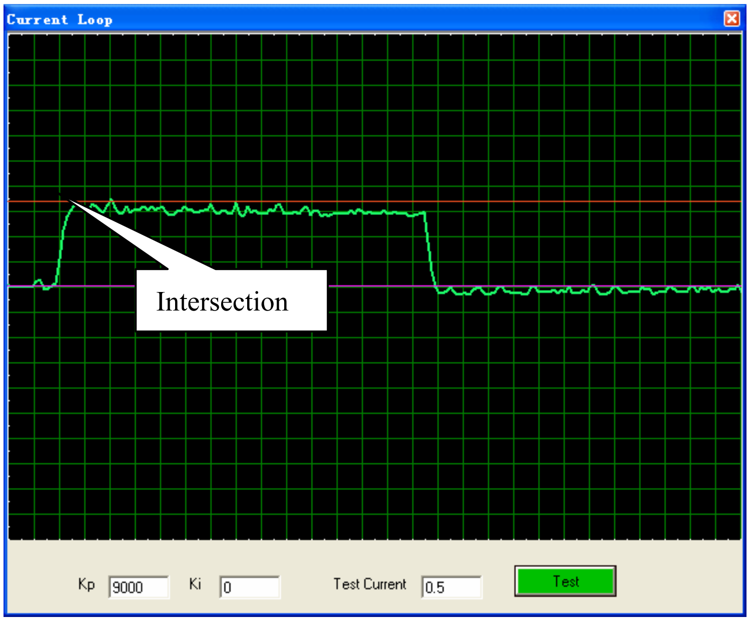
Ki = 0



↑ Proportional Gain:

Kp =7000

Ki = 0

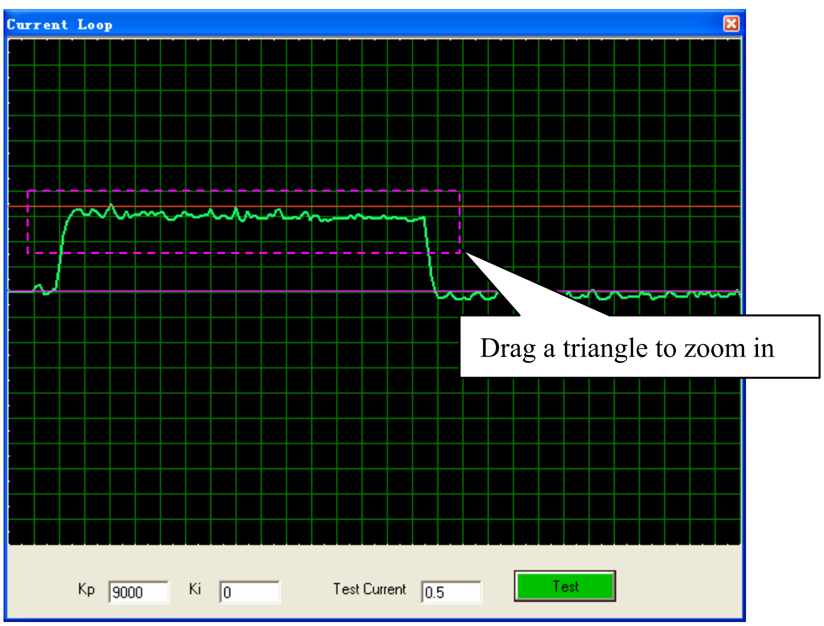


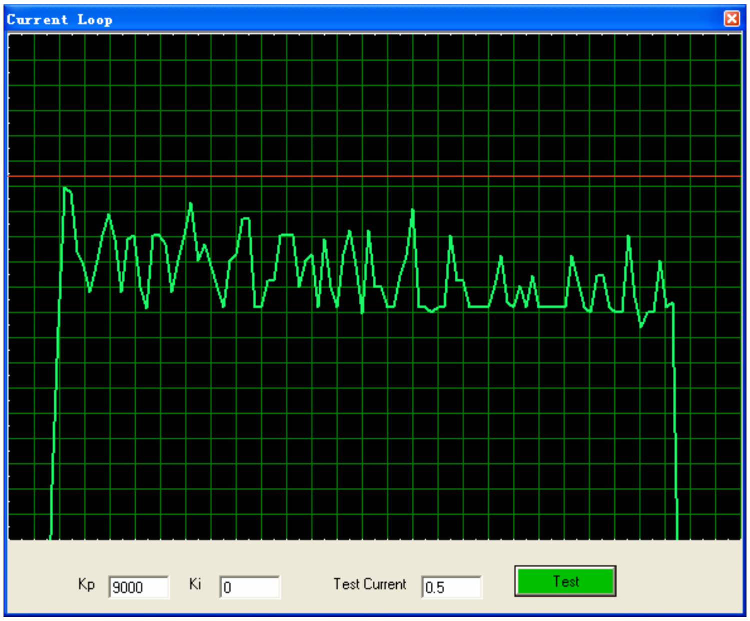
↑ Proportional Gain:

Kp =9000

Ki = 0

Step 4: Now the **Kp** is relatively good enough. But there is still distance between the green curve and the red curve when we use the mouse to zoom in the green curve. So we need to introduce **Ki** to reduce the distance or steady error at 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 Ki.

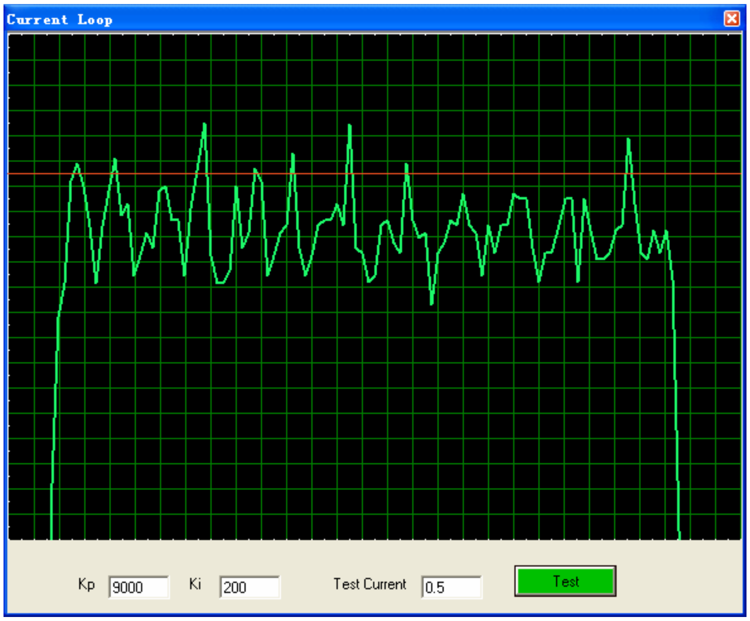




Zero Integral Gain:

Kp =9000

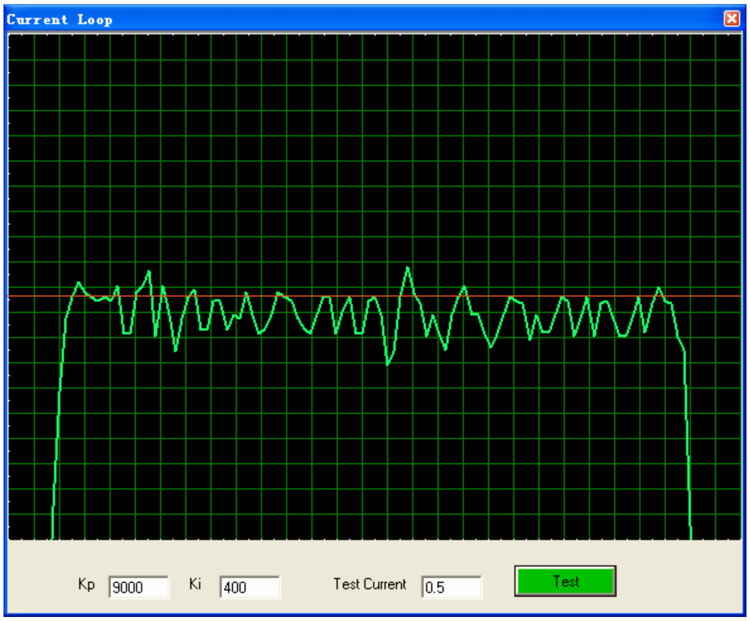
Ki = 1



↑ Integral Gain:

Kp =9000

Ki = 200



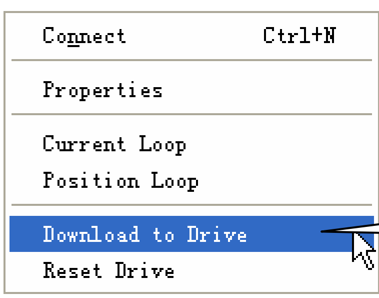
↑ Integral Gain:

Kp =Ki

Ki = 400

Step 5: The current loop tuning is basically finished. You can continue to adjust Kp and Ki for better performance. Now the updated Kp and Ki is just stored in the driver's RAM. They will be lost when we power off the driver. **Don't forget to click Drive->Download To Drive to store the changed value to the drive's nonvolatile EEPROM.**

Notice: You can reduce the Kp if the motor's noise can not be accepted for the application.



Save all the changes to the drive's non-violated nonvolatile memory.

Tuning the 1st Position Loop Parameters

Click **Drive->Position Loop** to open the tuning window. The follow example demonstrates the tuning of the 1st position loop base on a NEMA23 motor with 24VDC input.

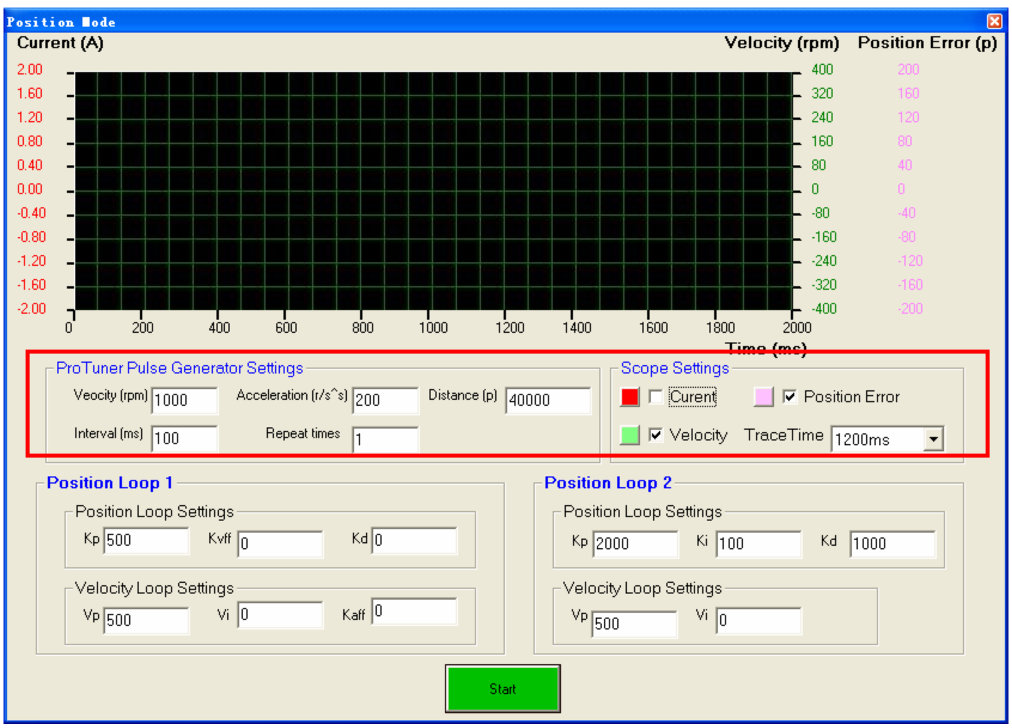
Notice

The motor should be installed to the machine and connected to load before the position loop tuning.

Caution

Move the load to the middle of the axis and make sure (40000/Encoder Resolution) turns of motor shaft will not hit anything. Otherwise, please reduce the distance setting in the pulse generator.

Before tuning the 1st position loop parameters, set pulse generator parameter as the following figure. We select the actual velocity and position following error to be displayed in the digital scope. **Trace Time** affects the display length of the curve. Here we select 1200ms.



Pulse Generator and Scope Settings in this Example:

Velocity = 1200rpm, Acceleration = 200r/s^2, Distance = 40000Pulse, Repeat Times = 1

Check the Velocity and Position Error Curve, Trace Time = 1200ms

The pulse generator will generate the following command trapezoid velocity profile. It takes 100ms to make the motor to accelerate from 0 to 1200 rpm.

Commanded Trapezoid Velocity Curve

Our purpose is to get the highest system stiffness but lower motor noise. The actual measured velocity should be similar as the commanded velocity curve. However, sometimes we need to trade off between them because high proportional gain leads to big overshoot and vibration. In this example, we start with small proportional gain then increase it. We will stop increasing when the motor noise can not be accepted. The **Kaff** and **Kvff** (Feed-forward gain) will be increased to further reduce the position following error if necessary. The tuning procedure is shown as follows:

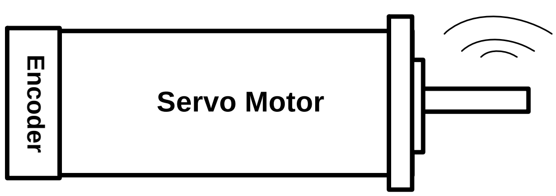
①**Kvff** = 0, **Kd** = 100, **Vi** =0, **Kaff** = 0, Small **Vp** and **Kp**

②**Vp**↑ , motor noise begins, **Vp**↓ ③**Kp**↑ , motor noise begins , **Kp**↓ ④**Kaff**↑, **Kvff**↑, **Kd**↑ (If necessary)

Step 1: Set **Vp** = 100, **Vi** = 0, **Kp** = 500, **Kaff** = 0, **Kd** = 0. The initial value is depending on supply voltage, motor and reflected load inertia. The above valuses may not suitable for your system. Please adjust them according to different symptom as follows:

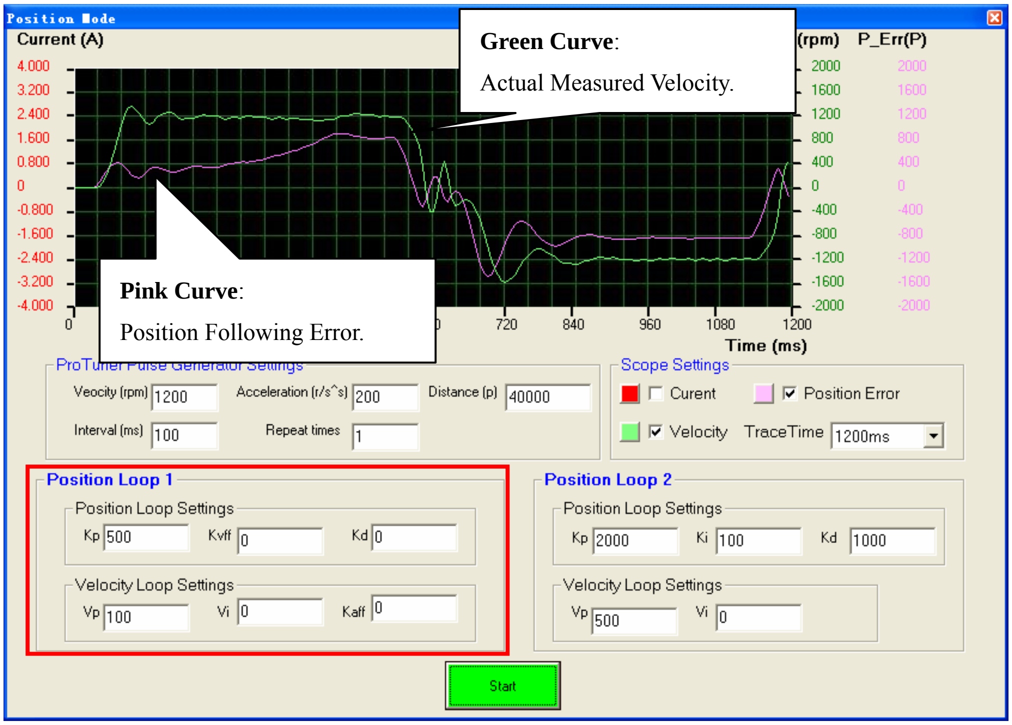
- Decrease **Vp/Kp** if the motor generates big noise.
- Increase **Vp/Kp** if the drive's red LED blinks (Protection mode).

Tip: Giving an external torque by rotating the motor shaft (or moving the load) manually is good way to check whether the **Vp** and **Vd** are suitable or not. If it is hard to rotate/move and the motor generates big noise, you should lower down **Vp**/**Kp**. If it is easy to rotate/move and even the drive goes into protection mode (the red LED blinks), you should increase **Vp**/**Kp**.



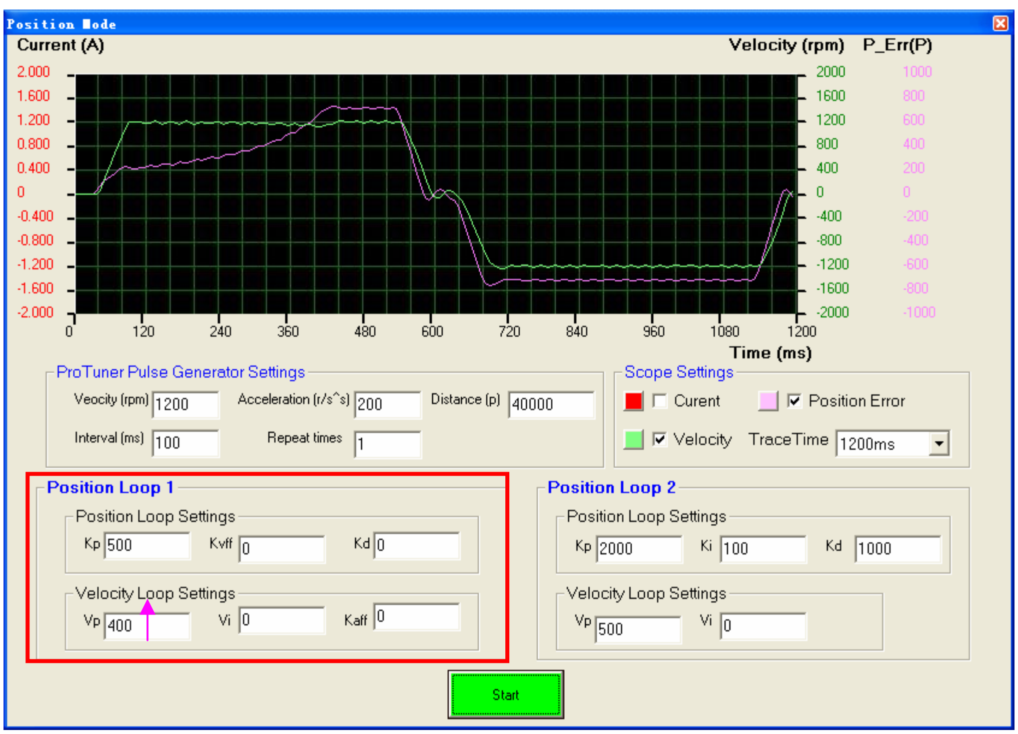
Observe the motor noise/vibration when increasing loop gain

Press the **Start** button to start the test. The motor shaft will move (40000/Encoder Resolution) turns in two directions. Several seconds later the actual measured velocity and position error curve are displayed in the scope as follows. We see that the position error is large and the velocity curve is very bad when comparing to the commanded one.

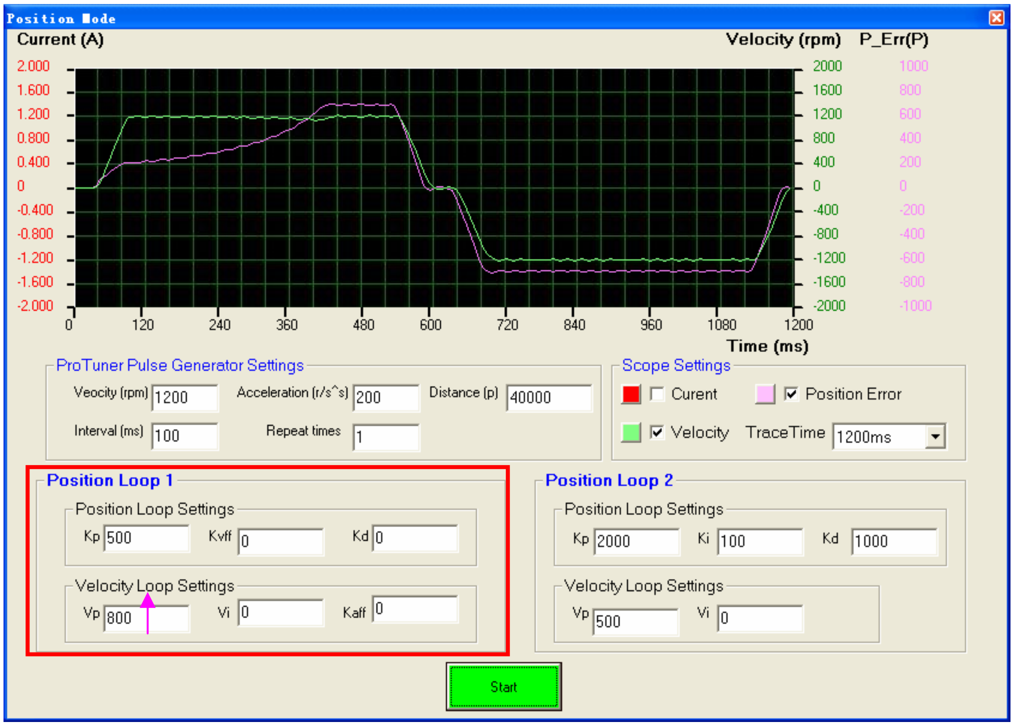


Kp = 500, Vp = 100,
Kvff = Kd = Vi = Kaff = 0

Step 2: Increase **Vp** until the actual velocity curve is like the commanded one. If the motor noise is large and can not be accepted, decrease it until it can be accepted. To activate the noise/vibration, sometimes you need to give a disturbance to the load by either clicking the **Start** button or trying to push/pull the load. In this example, we give **Vp** 400, 800, 1000 and find that the noise/vibration at **Vp**=1000 can be accepted. So we stop increasing **Vp**.

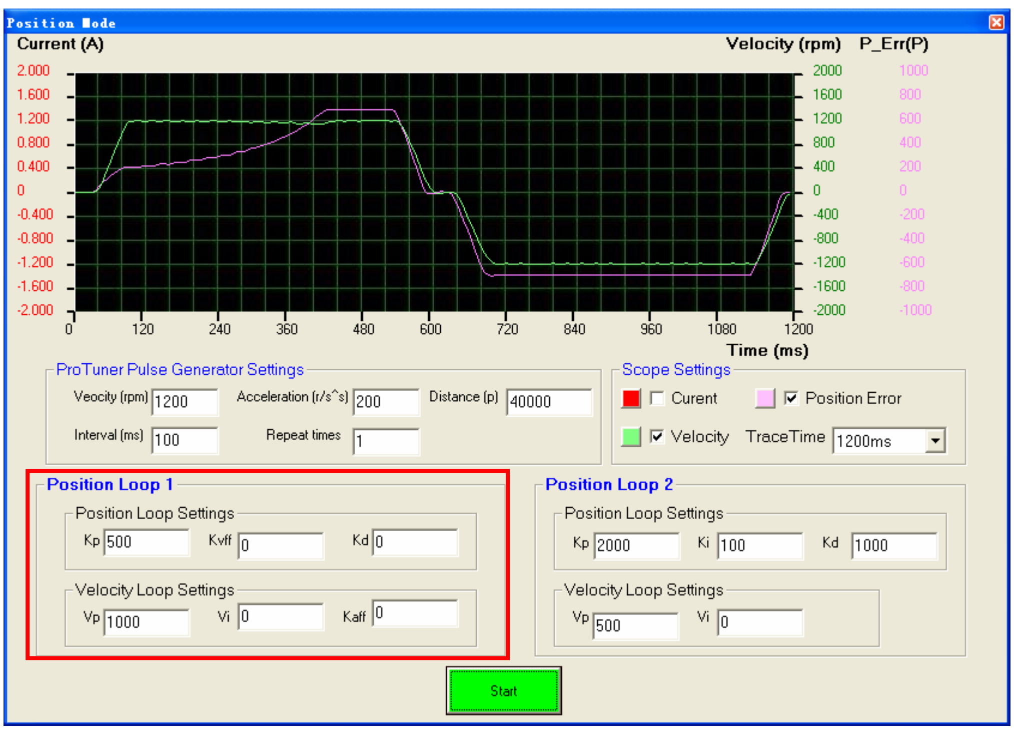


Kp = 500, ↑ Vp = 400,
Kvff = Kd = Vi = Kaff = 0



Kp = 500, ↑ Vp = 800,

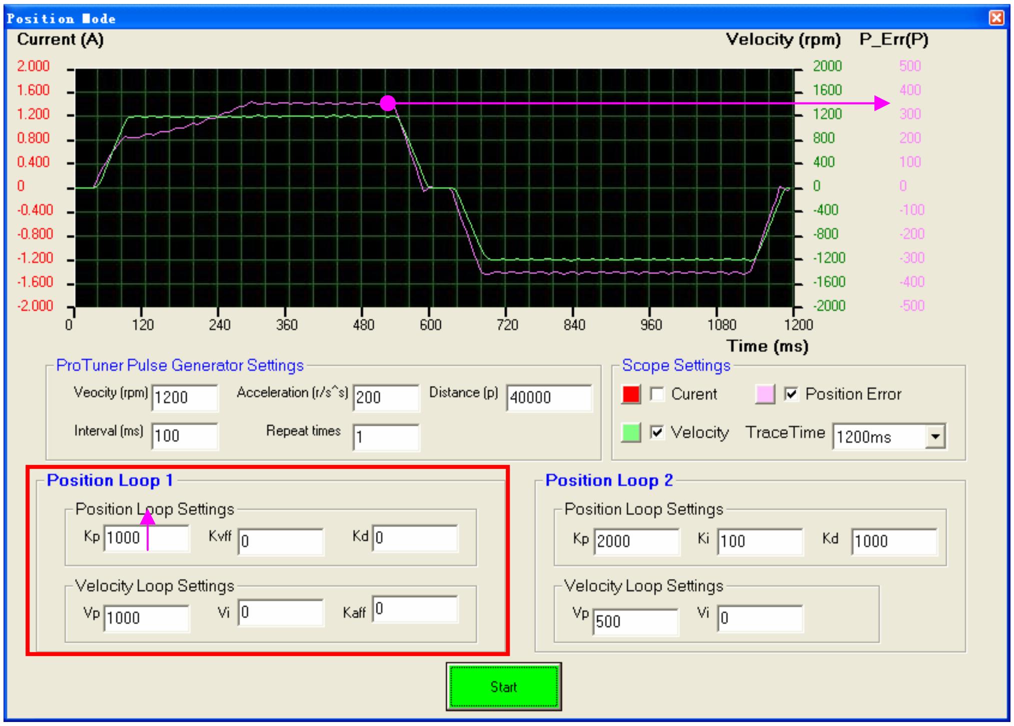
Kvff = Kd = Vi = Kaff = 0



Kp = 500, ↑ Vp = 1000,

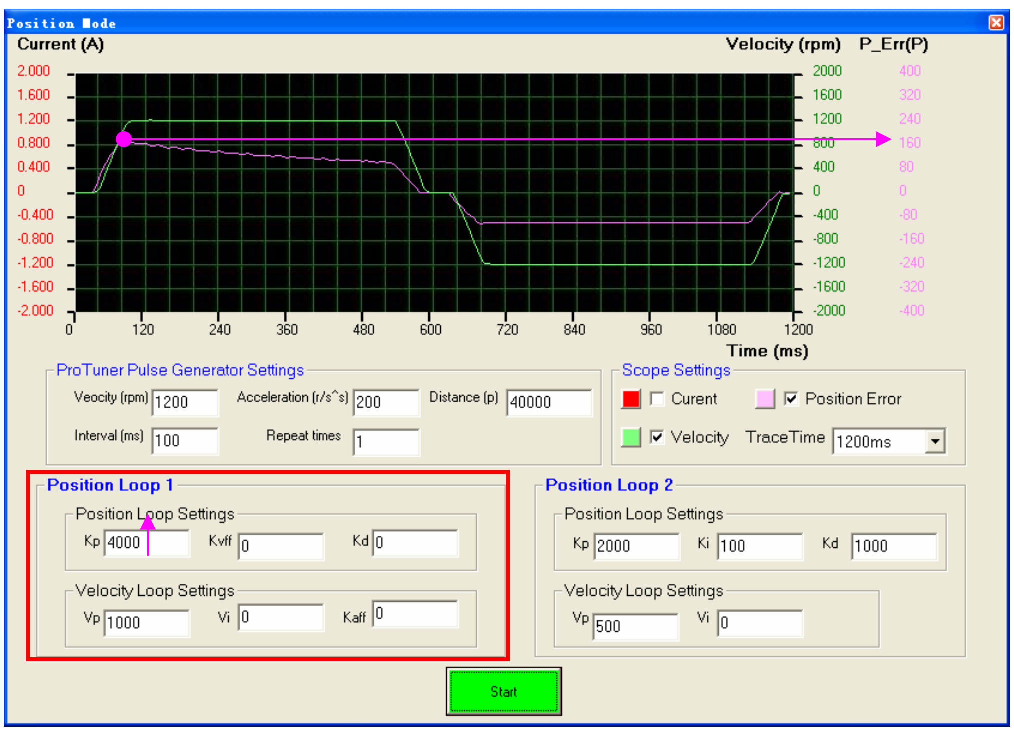
Kvff = Kd = Vi = Kaff = 0

Step 3: Increase **Kp** to maximize the system stiffness or minimize the position error until the motor noise/vibration can not be accepted, following the same way as **Vp**. See the figures below. We see that the peak position error reduce from 350 to 180 when increasing Kp to 4000.



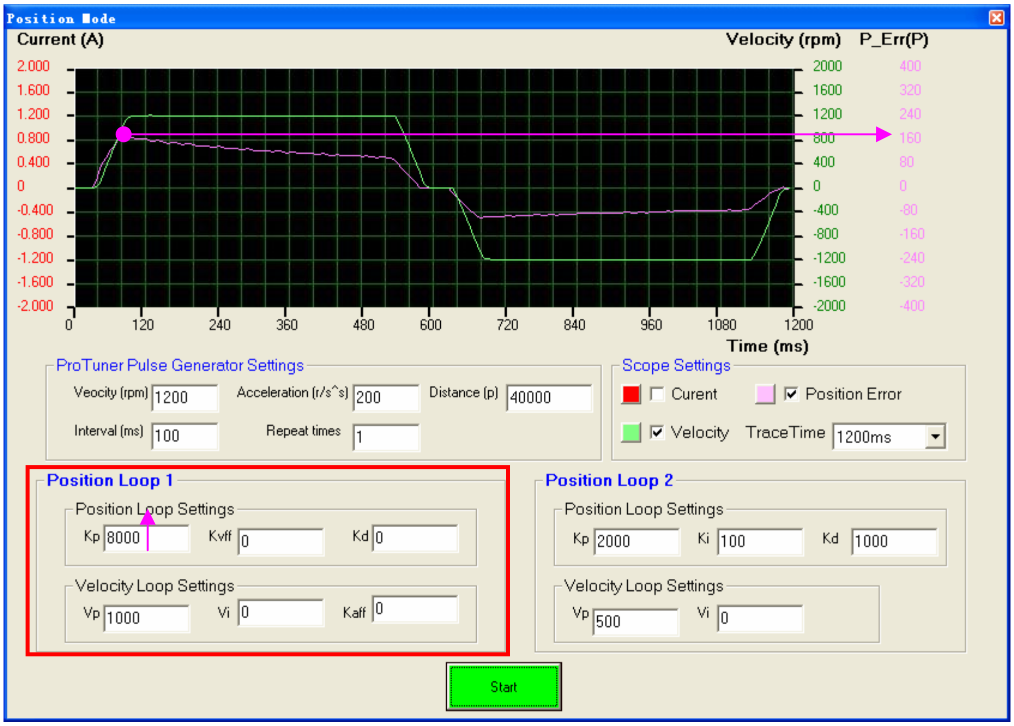
↑ Kp = 1000, Vp = 1000, Kvff = Kd = Vi = Kaff = 0

Position Error = 350



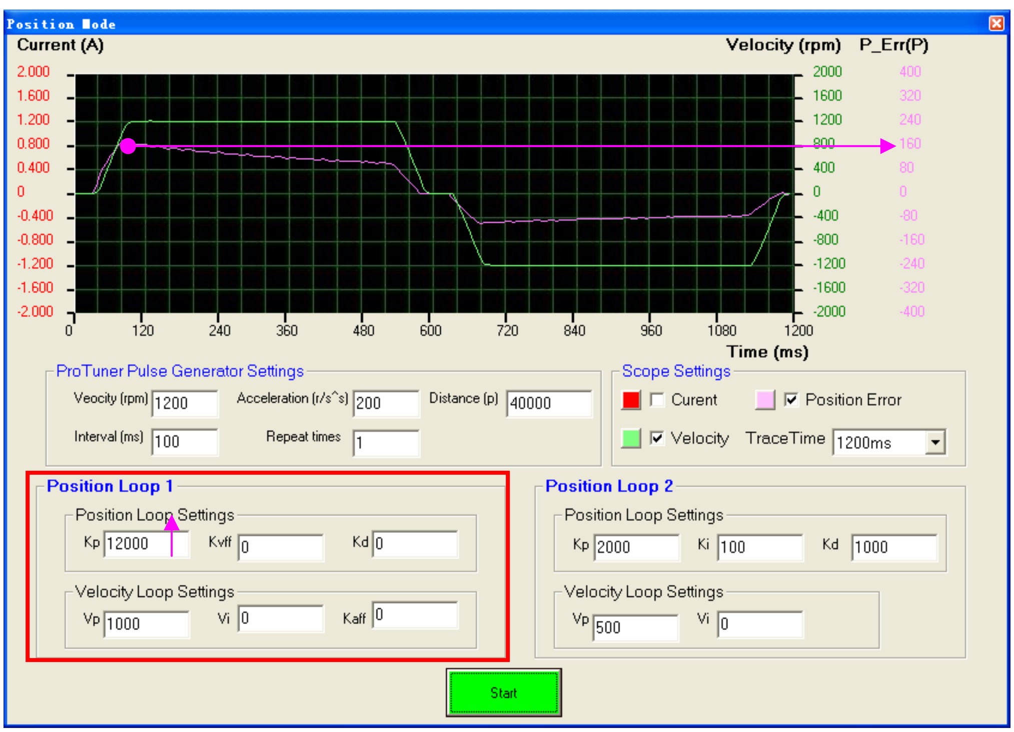
↑ Kp = 4000, Vp = 1000, Kvff = Kd = Vi = Kaff = 0

Position Error = 180



↑Kp = 8000, Vp = 1000, Kvff = Kd = Vi = Kaff = 0

Position Error = 170

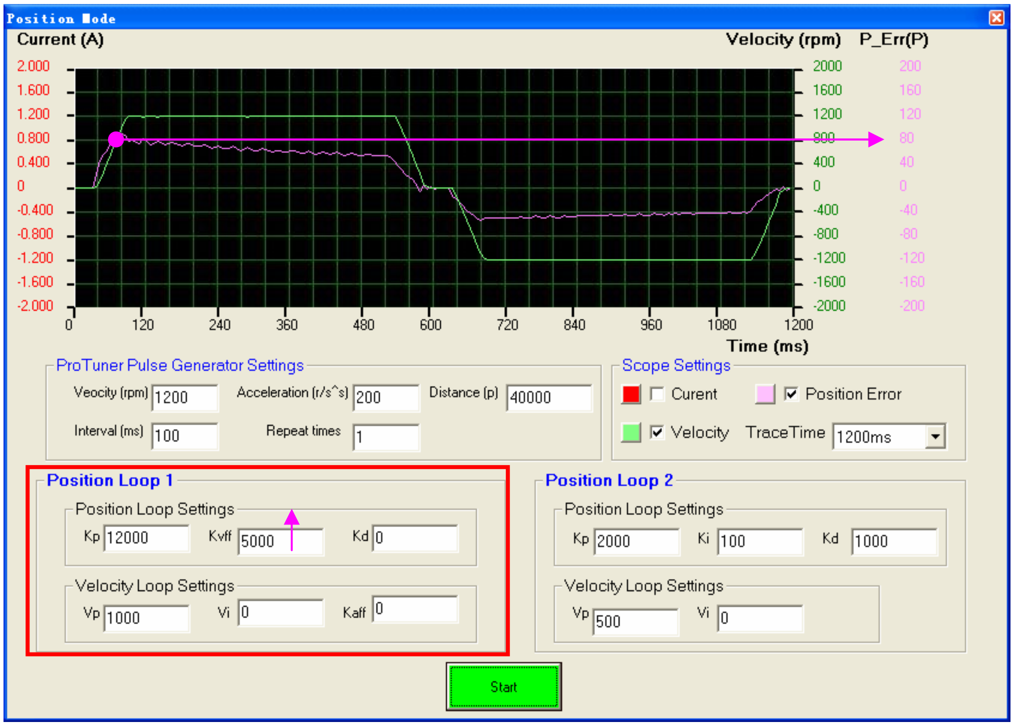


↑Kp = 12000, Vp = 1000, Kvff = Kd = Vi = Kaff = 0

Position Error = 160

Now the system has been basically tuned. In the following step, the user can increase Kvff to further reduce the position following error if necessary. However, big noise may be introduced if high Kvff.

Step 4: Increase the **Kvff** to 5000 and 10000. The position following error reduces to 80 and 30, respectively. See figures.

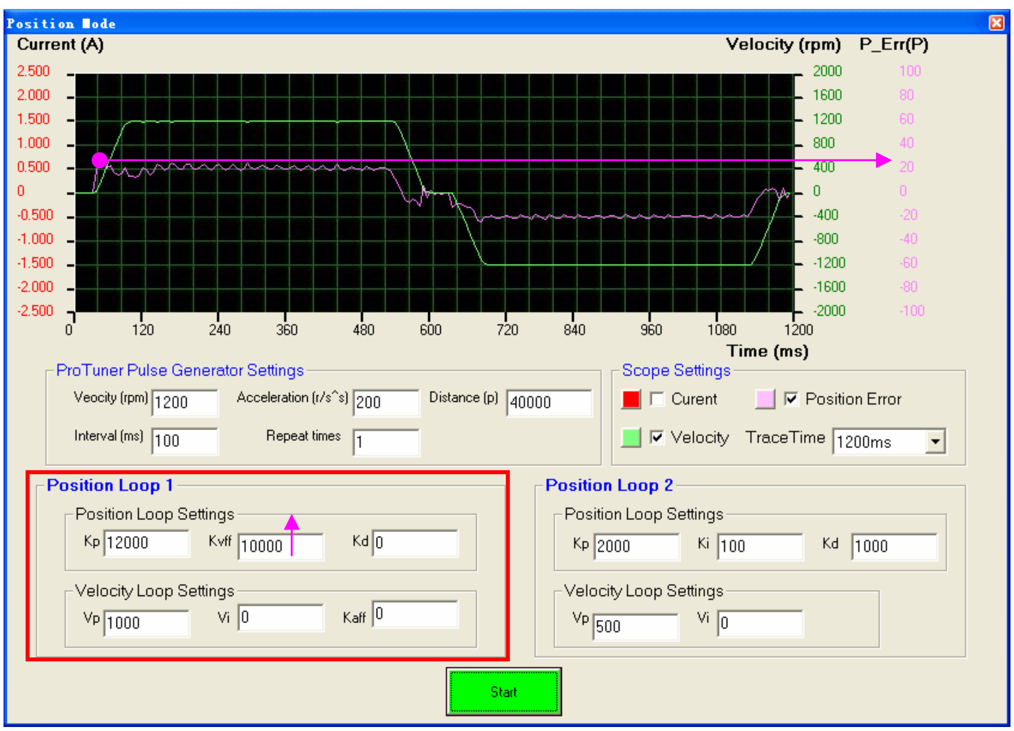


Kp = 12000, Vp = 1000,

↑ Kvff = 5000

Kd = Vi = Kaff = 0

Position Error = 80



Kp = 12000, Vp = 1000,

↑ Kvff = 10000

Kd = Vi = Kaff = 0

Position Error = 30

Remember that tuning the servo is to get satisfying performances, getting the best performances of the servo is a time consuming work. So if the servo performance can meet your application requirements, then the easier tuning way the better. Just like if the performances of the products can meet your application requirements, then the cheaper the better.

Step 5: Don't forget to click Drive->**Download To Drive** to store the changed value to the drive's nonvolatile EEPROM.

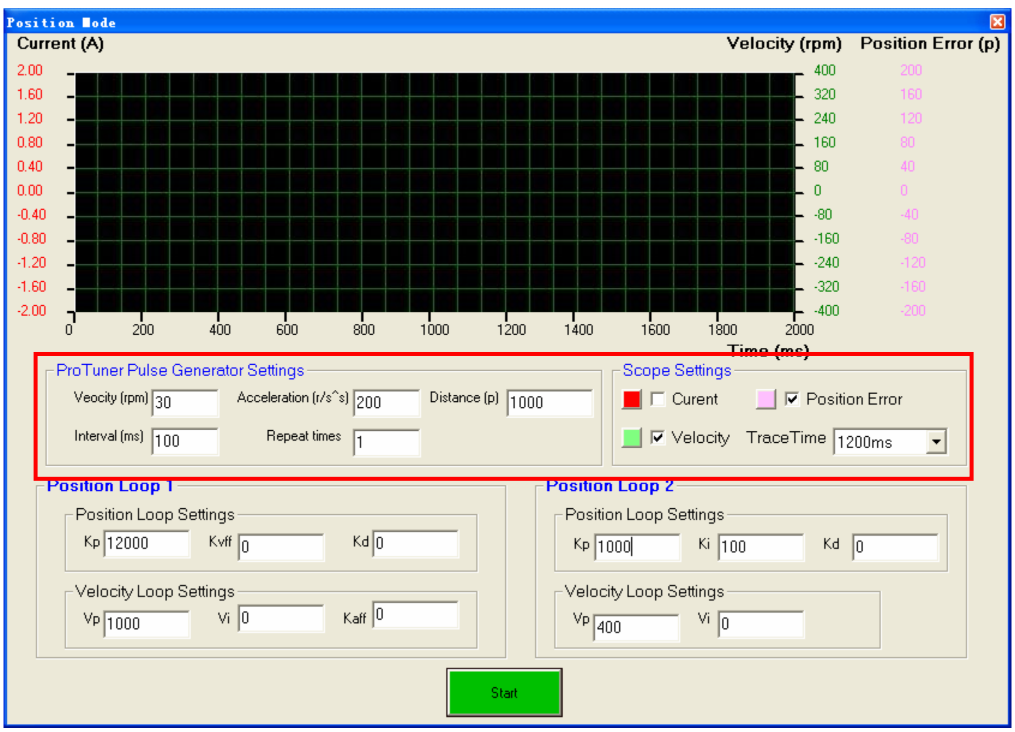
Tuning the 2nd Position Loop Parameters

Click **Drive->Position Loop** to open the tuning window. The follow example demonstrates the tuning of the 1st position loop base on a NEMA23 motor with 24VDC input.

Notice: The motor should be installed to the machine and connected to load before the position loop tuning.

Caution: Move the load to the middle of the axis and make sure (1000/Encoder Resolution) turns of motor shaft will not hit anything. Otherwise, please reduce the distance setting in the pulse generator.

Before tuning the 2nd position loop parameters, set pulse generator parameter as the following figure. We select the actual velocity and position following error to be displayed in the digital scope. **Trace Time** affects the display length of the curve. Here we select 1200ms.



Pulse Generator and Scope Settings in this Example:

Velocity = 30rpm, Acceleration = 200r/s^2, Distance = 1000Pulse, Repeat Times = 1

Check the Velocity and Position Error Curve, Trace Time = 1200ms

The pulse generator will generate the following command trapezoid velocity profile. It takes 2.5ms to make the motor to accelerate from 0 to 30 rpm.

Commanded Trapezoid Velocity Curve

Our purpose is to get the highest system stiffness but lower motor noise. The actual measured velocity should be similar as the commanded velocity curve. However, sometimes we need to trade off between them because high proportional gain leads to big overshoot and vibration. In this example, we start with small proportional gain then increase it. We will stop increasing when the motor noise can not be accepted. The tuning procedure is shown as follows:

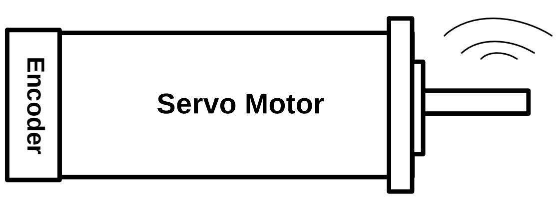
①**Kd** = 100, **Ki** =100, Vi = 0, Small **Vp** and **Kp**

②**Vp**↑ , motor noise begins, **Vp**↓ ③**Kp**↑ , motor noise begins , **Kp**↓ ④**Kd**↑, **Ki**↑(If necessary)

Step 1: Set **Vp** = 400, **Vi** = 0, **Kp** = 1000, **Ki**= 100, **Kd** = 100. The initial value is depending on supply voltage, motor and reflected load inertia. The above valuses may not suitable for your system. Please adjust them according to different symptom as follows:

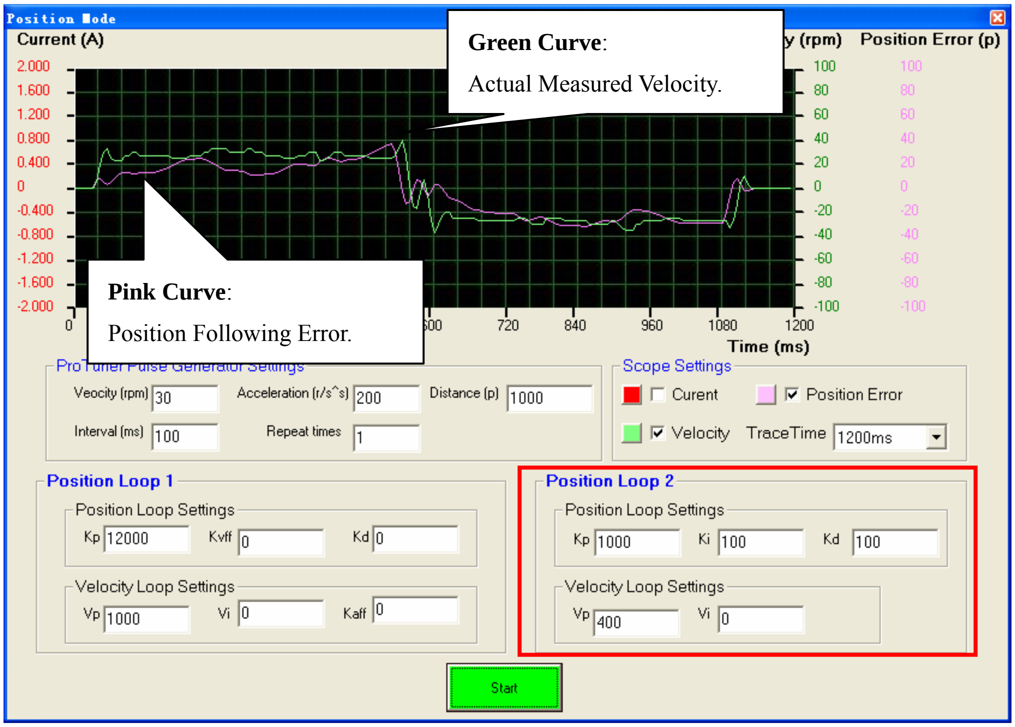
- Decrease **Vp/Kp** if the motor generates big noise.
- Increase **Vp/Kp** if the drive's red LED blinks (Protection mode) or the motor vibrates.

Tip: Giving an external torque by rotating the motor shaft (or moving the load) manually is good way to check whether the **Vp** and **Kp** are suitable or not. If it is hard to rotate/move and the motor generates big noise, you should lower down **Vp**/**Kp**. If it is easy to rotate/move and even the drive goes into protection mode (the red LED blinks), you should increase **Vp**/**Kp**.



Observe the motor noise/vibration when increasing loop gain

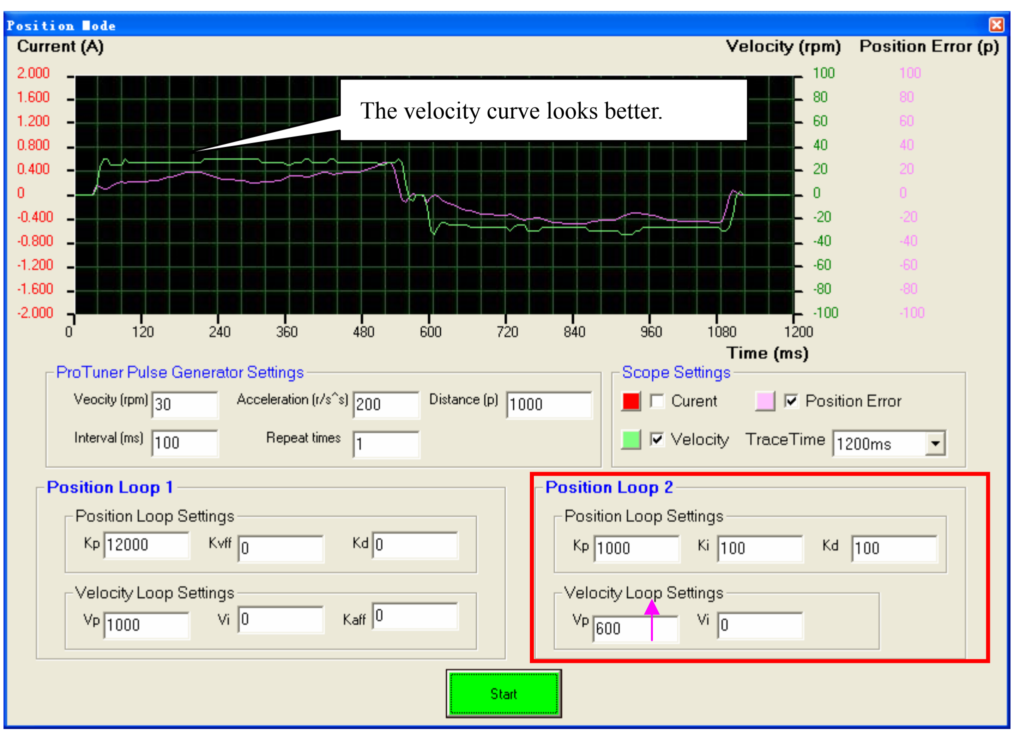
Press the **Start** button to start the test. The motor shaft will move (1000/Encoder Resolution) turns in two directions. Several seconds later the actual measured velocity and position error curve are displayed in the scope as follows. We see that the position error is large and the velocity curve is very bad when comparing to the commanded one.



Kp = 1000, Vp = 400

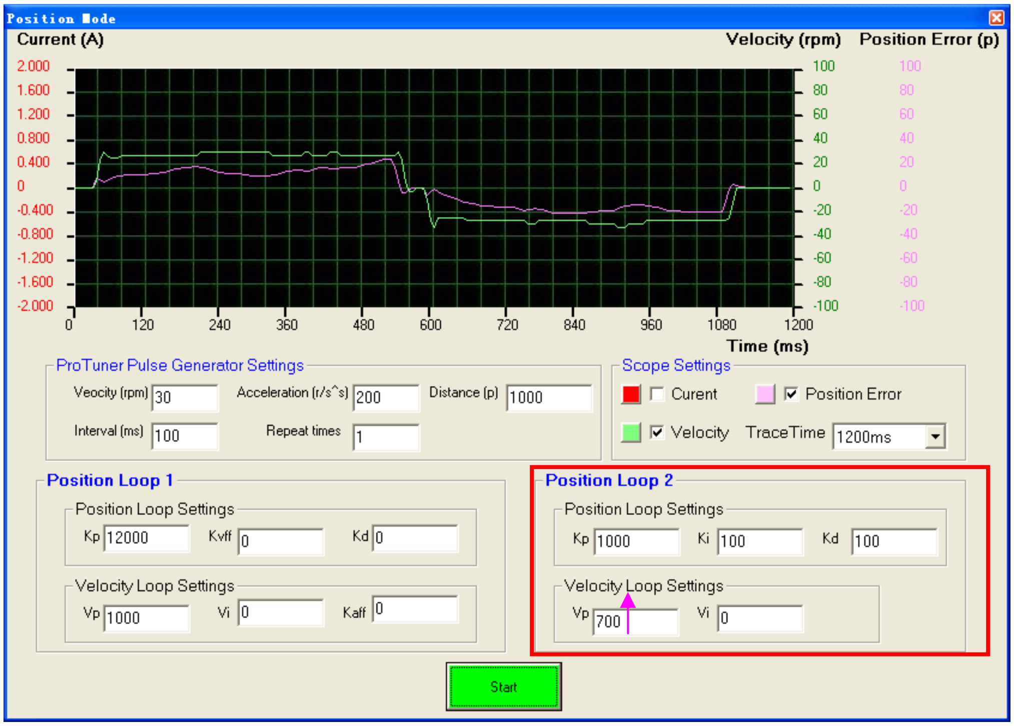
Ki= Kd = 100, Vi = 0

Step 2: Increase **Vp** until the actual velocity curve is like the commanded one. If the motor noise is large and can not be accepted, decrease it until it can be accepted. To activate the noise/vibration, sometimes you need to give a disturbance to the load by either clicking the **Start** button or trying to push/pull the load. In this example, we give **Vp** 600, 700,800 and find that the noise/vibration at **Vp**=800 can be accepted. So we stop increasing **Vp**.



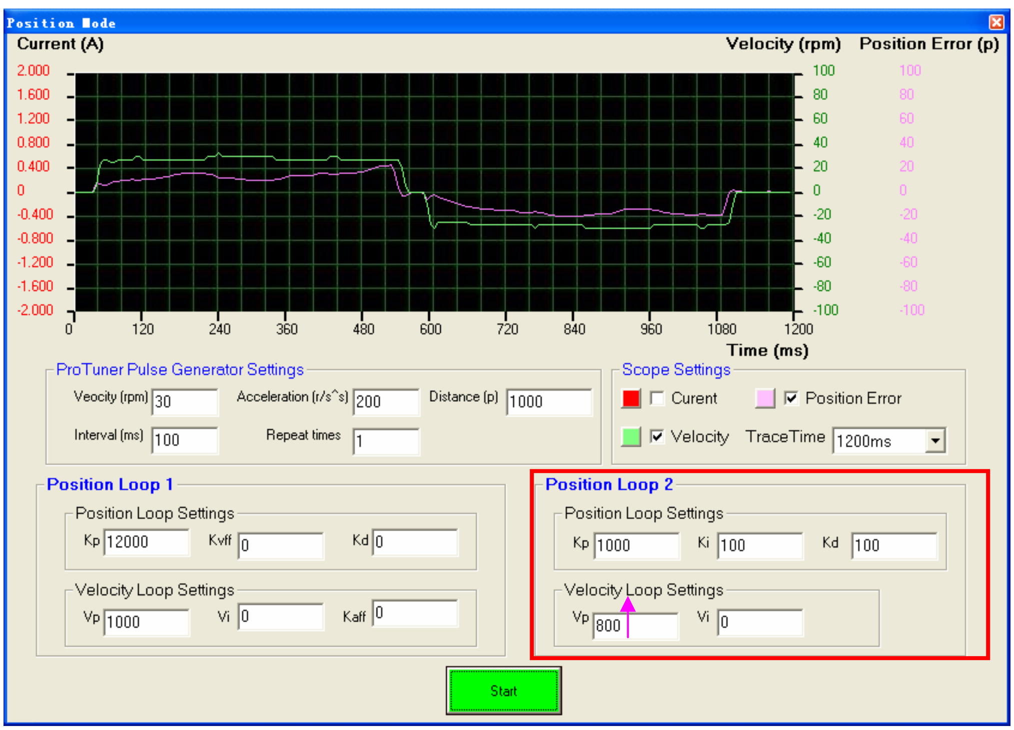
Kp = 1000, ↑Vp = 600

Ki= Kd = 100, Vi = 0



Kp = 1000, ↑Vp = 700

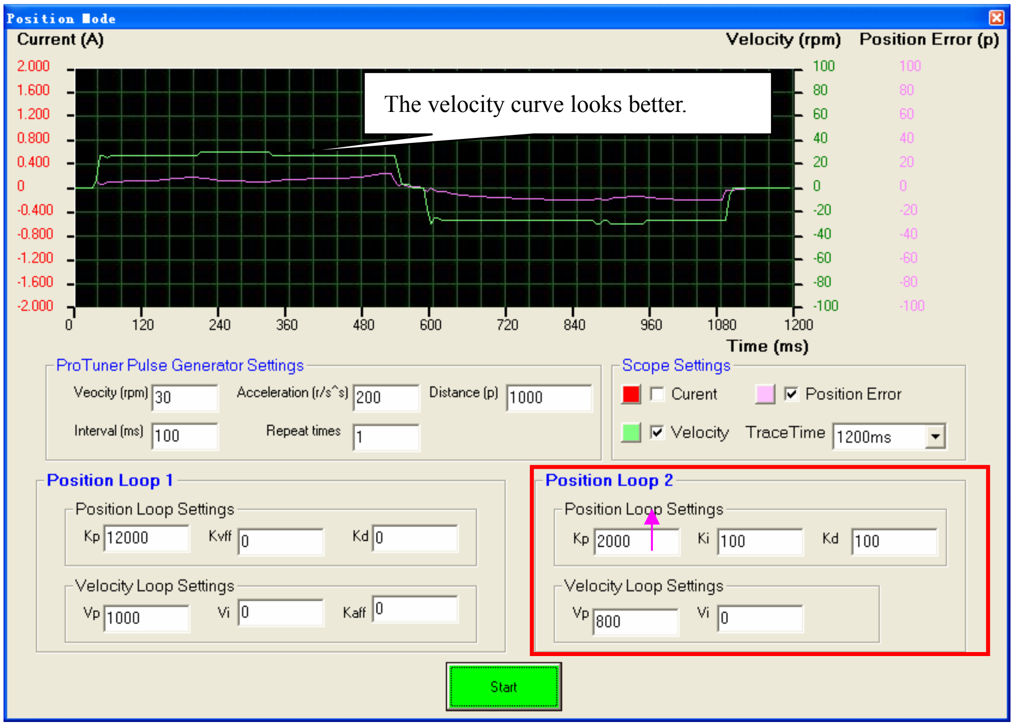
Ki= Kd = 100, Vi = 0



Kp = 1000, ↑Vp = 800

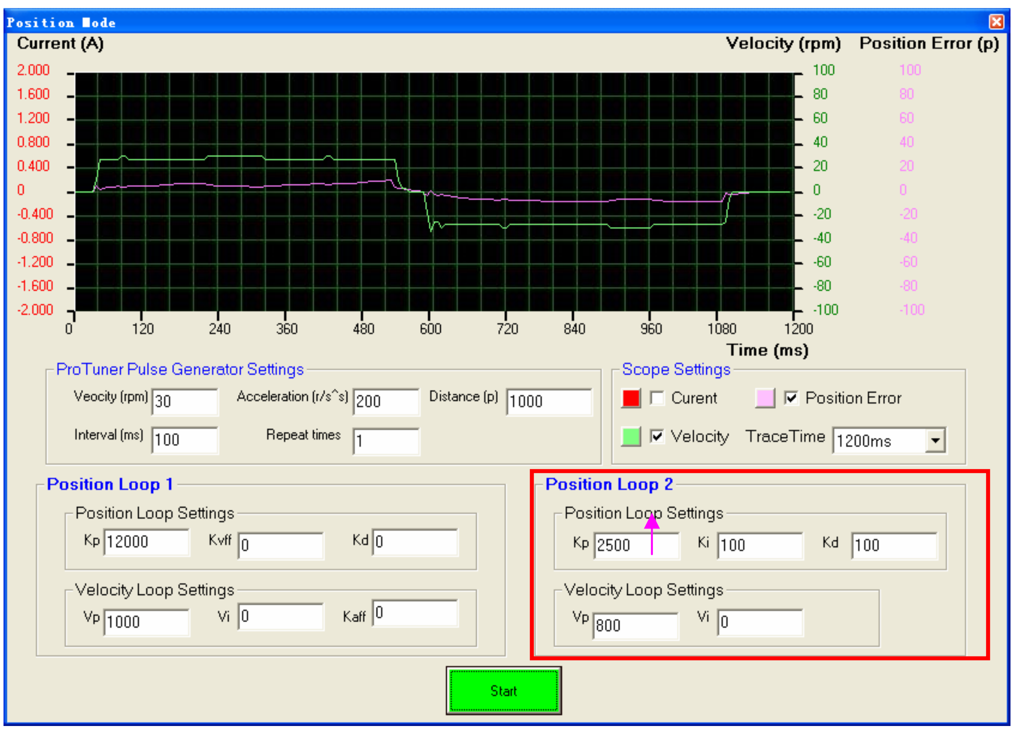
Ki= Kd = 100, Vi = 0

Step 3: Increase **Kp** to maximize the system stiffness or minimize the position error until the motor noise/vibration can not be accepted, following the same way as **Vp**. See the figures below. We see that the peak position error reduce a lot when increasing Kp to 2000.



↑ Kp = 2000, Vp = 800

Ki= Kd = 100, Vi = 0

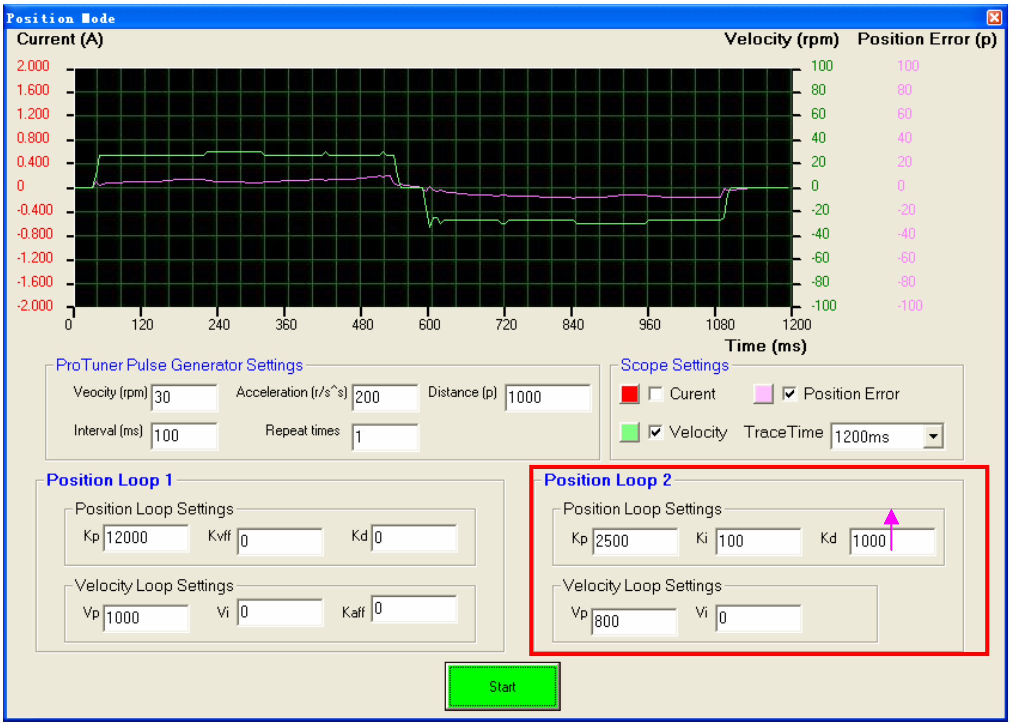


↑ Kp = 2500, Vp = 800

Ki= Kd = 100, Vi = 0

Now the system has been basically tuned. In the following step, the user can increase Kd to make the curve look more like the commanded one if necessary. However, the Kd is not sensitive.

Step 4: Increase the **Kvff** to 5000 and 10000. The position following error reduces to 80 and 30, respectively. See figures.



Kp = 2500, Vp = 800

↑Kd = 1000

Ki= 100, Vi = 0

Remember that tuning the servo is to get satisfying performances, getting the best performances of the servo is a time consuming work. So if the servo performance can meet your application requirements, then the easier tuning way the better. Just like if the performances of the products can meet your application requirements, then the cheaper the better.

Step 5: Don't forget to click **Drive->Download To Drive** to store the changed value to the drive's nonvolatile EEPROM**.**

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