PID調整
ST40 螺桿定位台

TSM17Q-2RG + RGS08

2023/12/1　　紀錄者: SW

PID 手冊說明

TSM一體型步進伺服馬達PID調整

https://montrol.com.tw/tsm%e4%b8%80%e9%ab%94%e5%9e%8b%e6%ad%a5%e9%80%b2%e4%bc%ba%e6%9c%8d%e9%a6%ac%e9%81%94pid%e8%aa%bf%e6%95%b4-2/

測試規格

ST40E430-7Q2R　　螺桿定位台

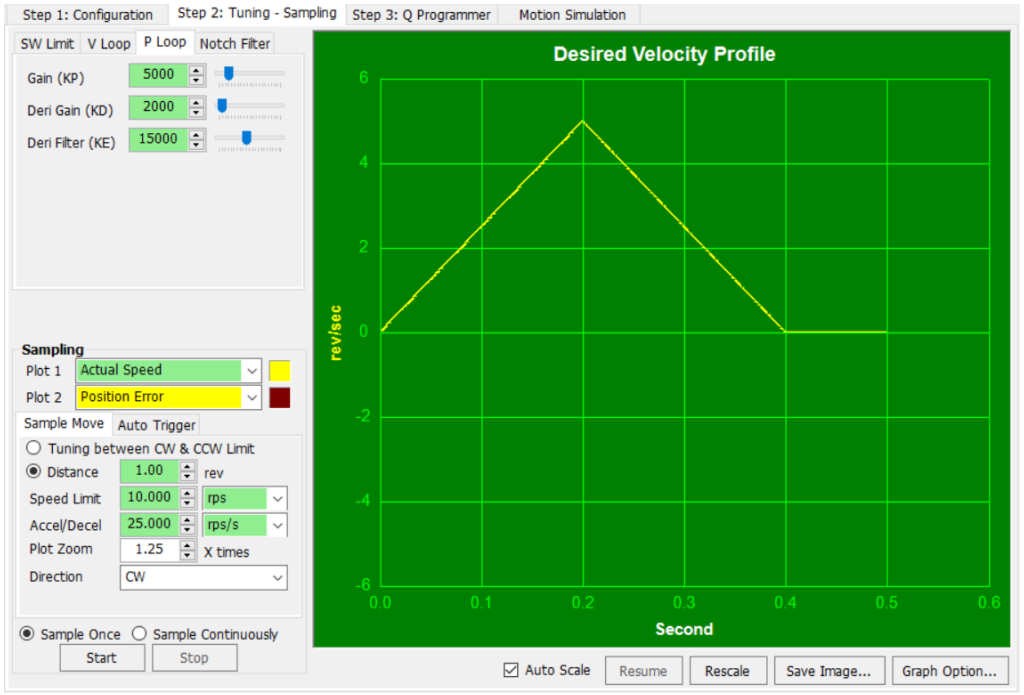
*規格: 行程 12”　(300mm+) & 導程: 6.35mm/sec

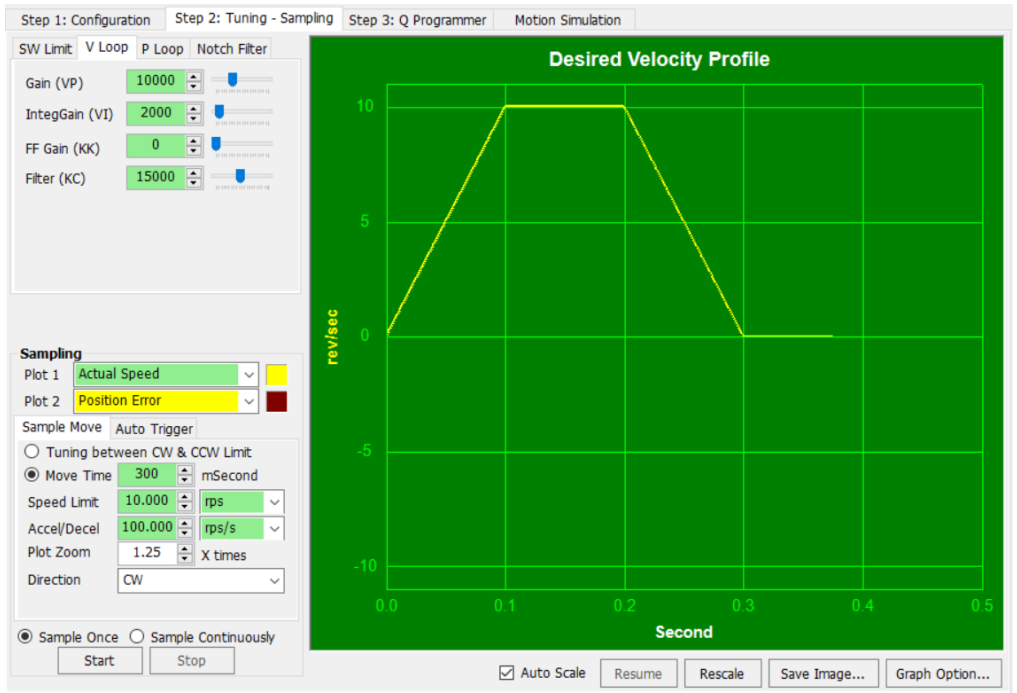
調整前影片

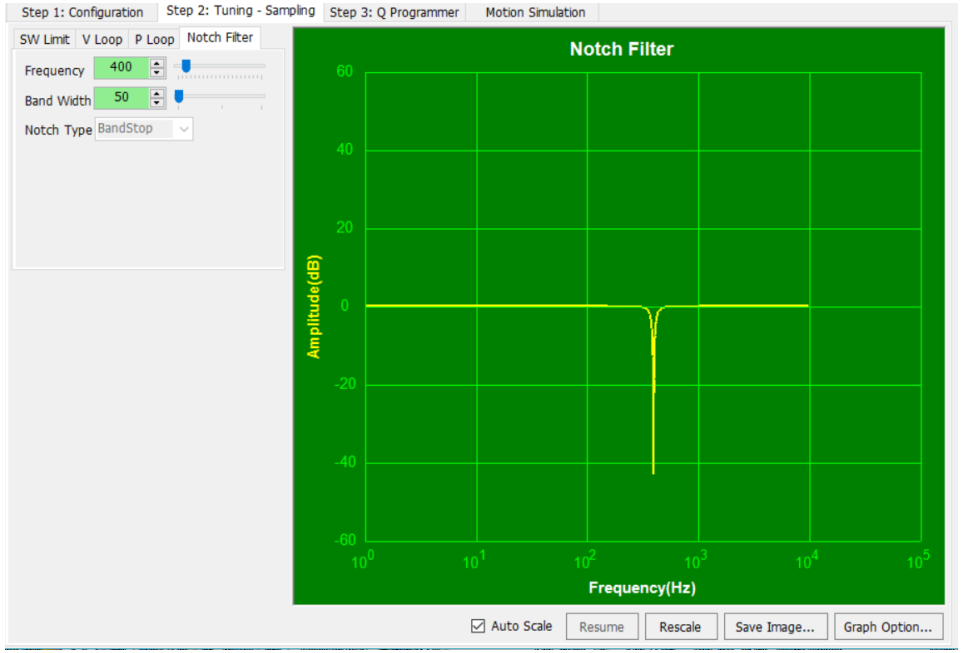
https://youtu.be/hmK54UPmn2o?si=E-lCf5LB10XSIuw4

調整前

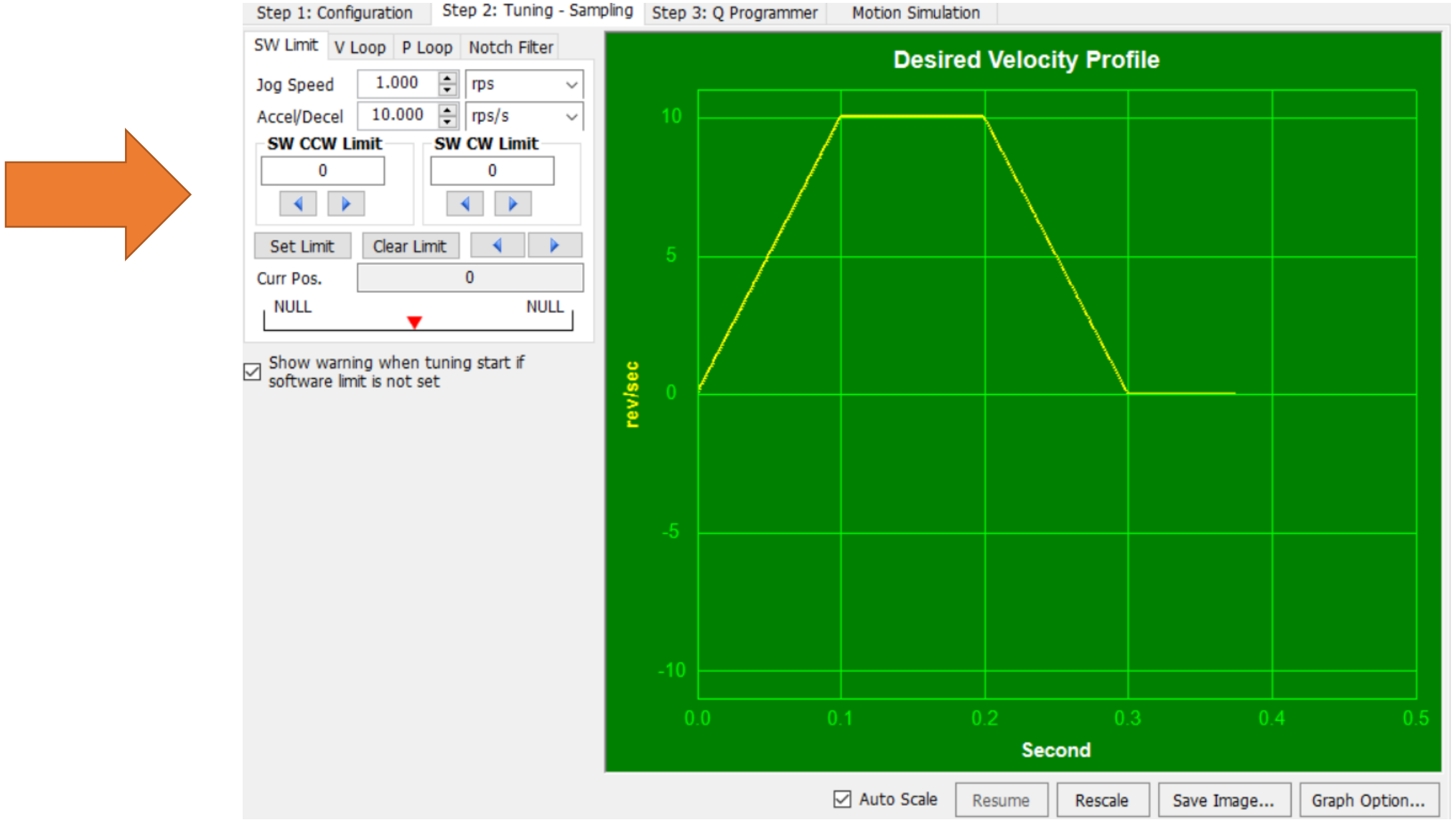

Step 1: Configuration
Step 2: Tuning - Sampling
Step 3: Q Programmer
Motion Simulation
SW Limit
V Loop
P Loop
Notch Filter
Jog Speed 1.000 rps
Accel/Decel 10.000 rps/s
SW CCW Limit
SW CW Limit
Set Limit
Clear Limit
Curr Pos. 0
NULL
NULL
Show warning when tuning start if software limit is not set
Desired Velocity Profile
rev/sec
Second
Auto Scale
Resume
Rescale
Save Image...
Graph Option...


Step 1: Configuration
Step 2: Tuning - Sampling
Step 3: Q Programmer
Motion Simulation
SW Limit
V Loop
P Loop
Notch Filter
Gain (KP) 5000
Deri Gain (KD) 2000
Deri Filter (KE) 15000
Sampling
Plot 1 Actual Speed
Plot 2 Position Error
Sample Move
Auto Trigger
Tuning between CW & CCW Limit
Distance 1.00 rev
Speed Limit 10.000 rps
Accel/Decel 25.000 rps/s
Plot Zoom 1.25 X times
Direction CW
Sample Once
Sample Continuously
Start
Stop
Desired Velocity Profile
rev/sec
Second
Auto Scale
Resume
Rescale
Save Image...
Graph Option...


Step 1: Configuration
Step 2: Tuning - Sampling
Step 3: Q Programmer
Motion Simulation
SW Limit
V Loop
P Loop
Notch Filter
Gain (VP) 10000
IntegGain (VI) 2000
FF Gain (KK) 0
Filter (KC) 15000
Sampling
Plot 1 Actual Speed
Plot 2 Position Error
Sample Move
Auto Trigger
Tuning between CW & CCW Limit
Move Time 300 mSecond
Speed Limit 10.000 rps
Accel/Decel 100.000 rps/s
Plot Zoom 1.25 X times
Direction CW
Sample Once
Sample Continuously
Start
Stop
Desired Velocity Profile
rev/sec
Second
Auto Scale
Resume
Rescale
Save Image...
Graph Option...


Step 1: Configuration
Step 2: Tuning - Sampling
Step 3: Q Programmer
Motion Simulation
SW Limit
V Loop
P Loop
Notch Filter
Frequency 400
Band Width 50
Notch Type BandStop
Notch Filter
Amplitude(dB)
Frequency(Hz)
Auto Scale
Resume
Rescale
Save Image...
Graph Option...

調整前, 先設定好滑台左右極限SW CCW Limit與 SW CW Limit



步驟一：將**速度環**增益起始設置為低值

(1) 將KC值設為預設值15000

(2) 將VI值與KK值設為0

(3) 對於低慣性負載與低加速度/減速度，將VP值設為1000~1500範圍內

(4) 並點擊”Download All to Drive”以完成修改。

步驟二：執行範例動作並調整VP值

(1) 繪製實際速度(Plot 1)與目標速度(Plot 2)曲線圖

(2) 將方向(Direction)設置為CW，然後選擇單次運行
(Sample Once)

(3) 觀察實際速度曲線，如圖(2a)

(4) 重複執行範例動作並調整VP值，直到實際速度介於目標速度的80-90%之間。此最終VP值設置會根據馬達負載與速度限制值之設置而有所不同。

調整VP值重點在於，實際速度曲線的頂部應平滑，無任何振盪，如圖(2b)、(2c)，並且移動完成後，馬達不應該發出任何噪音或震動。

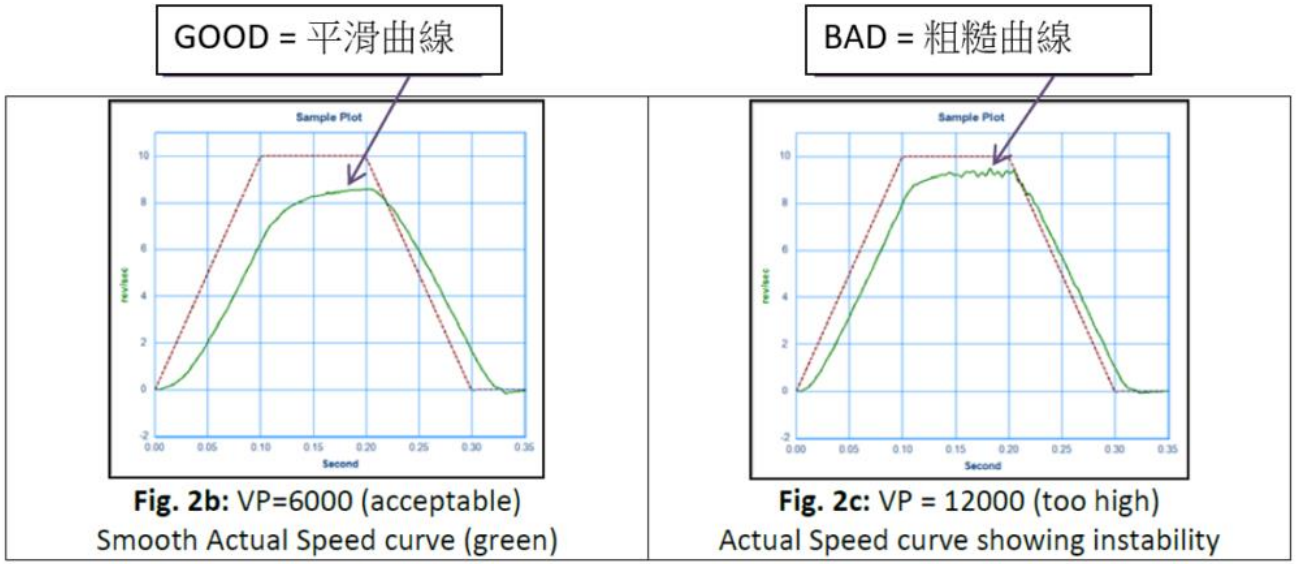


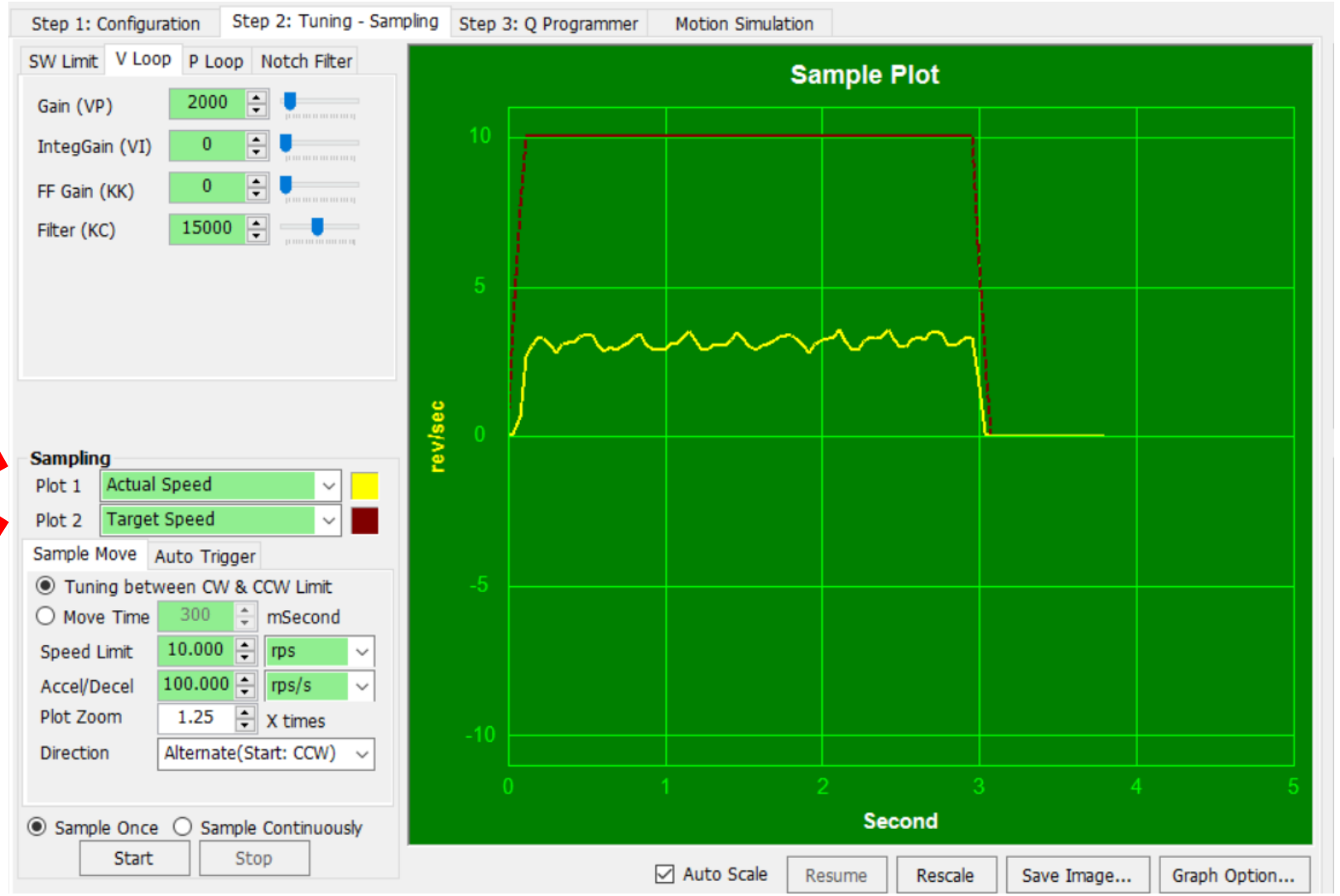
Fig. 2b: VP=6000 (acceptable)
Smooth Actual Speed curve (green)

Fig. 2c: VP = 12000 (too high)
Actual Speed curve showing instability

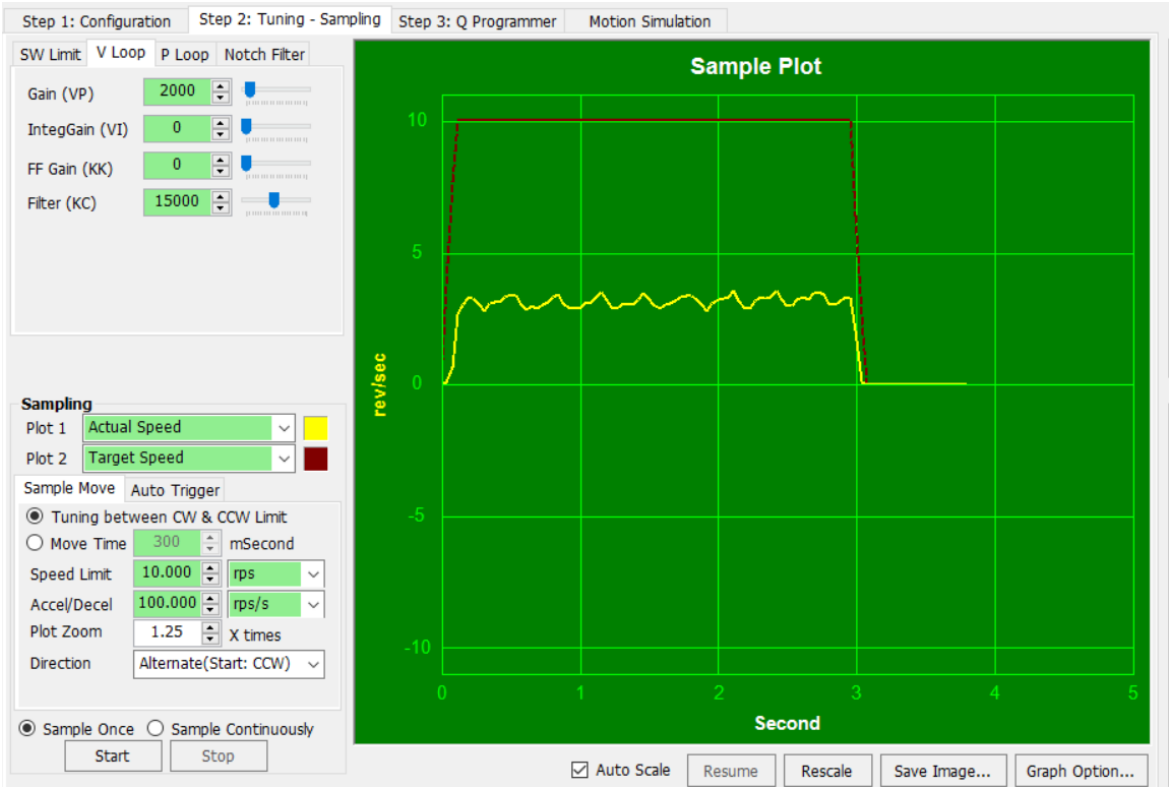
24VDC

Plot 1:
Actual Speed

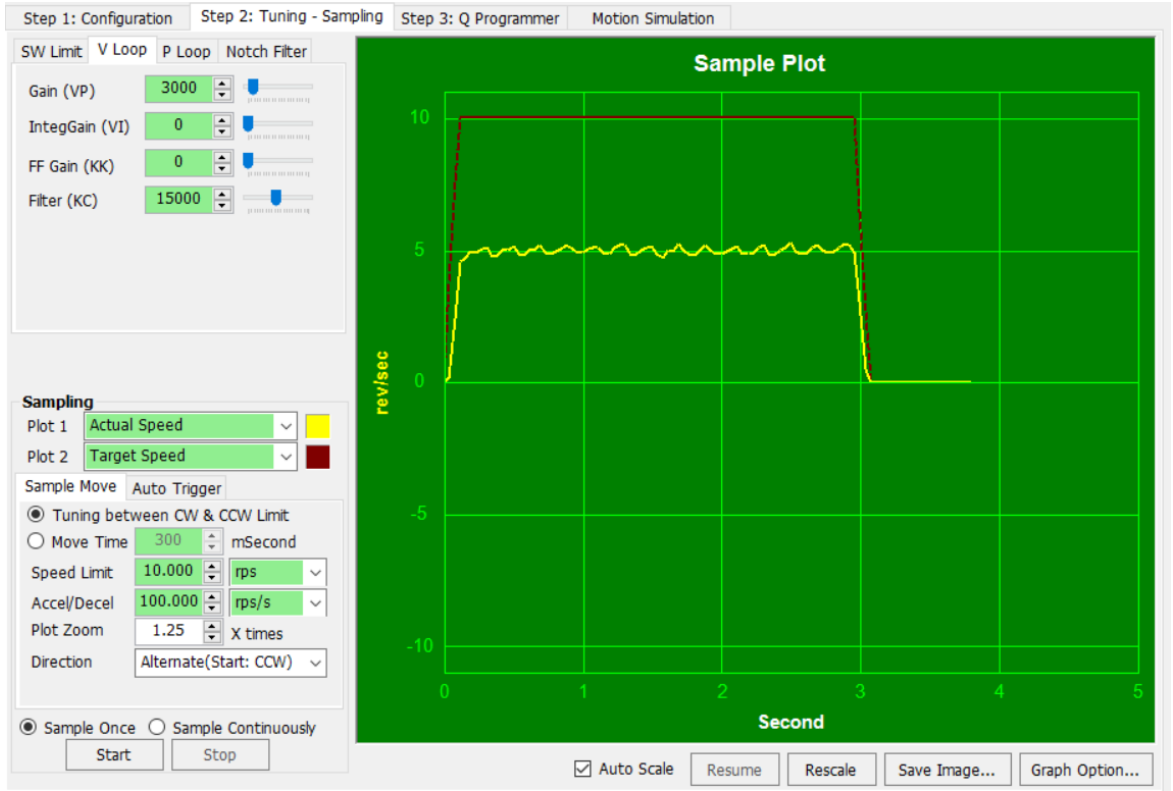
Plot 2:
Target Speed



24VDC

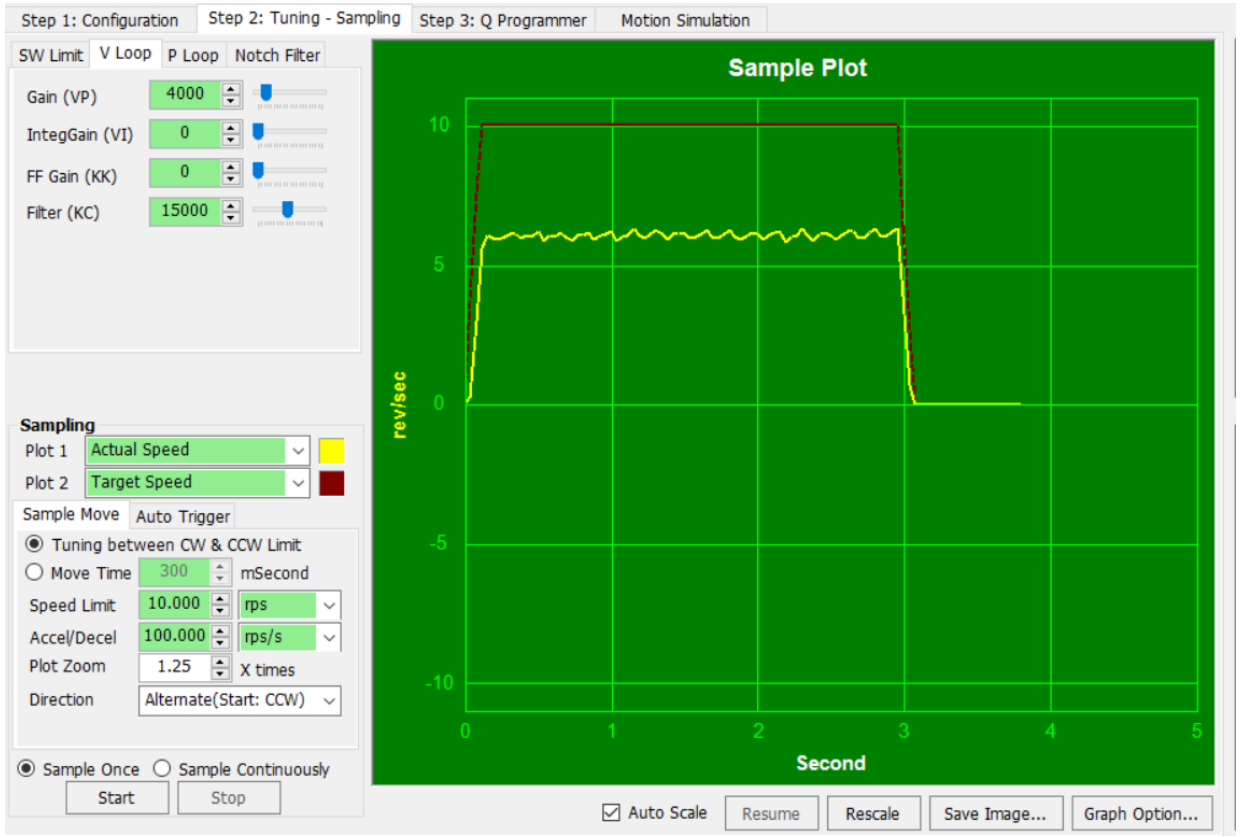


VP2000

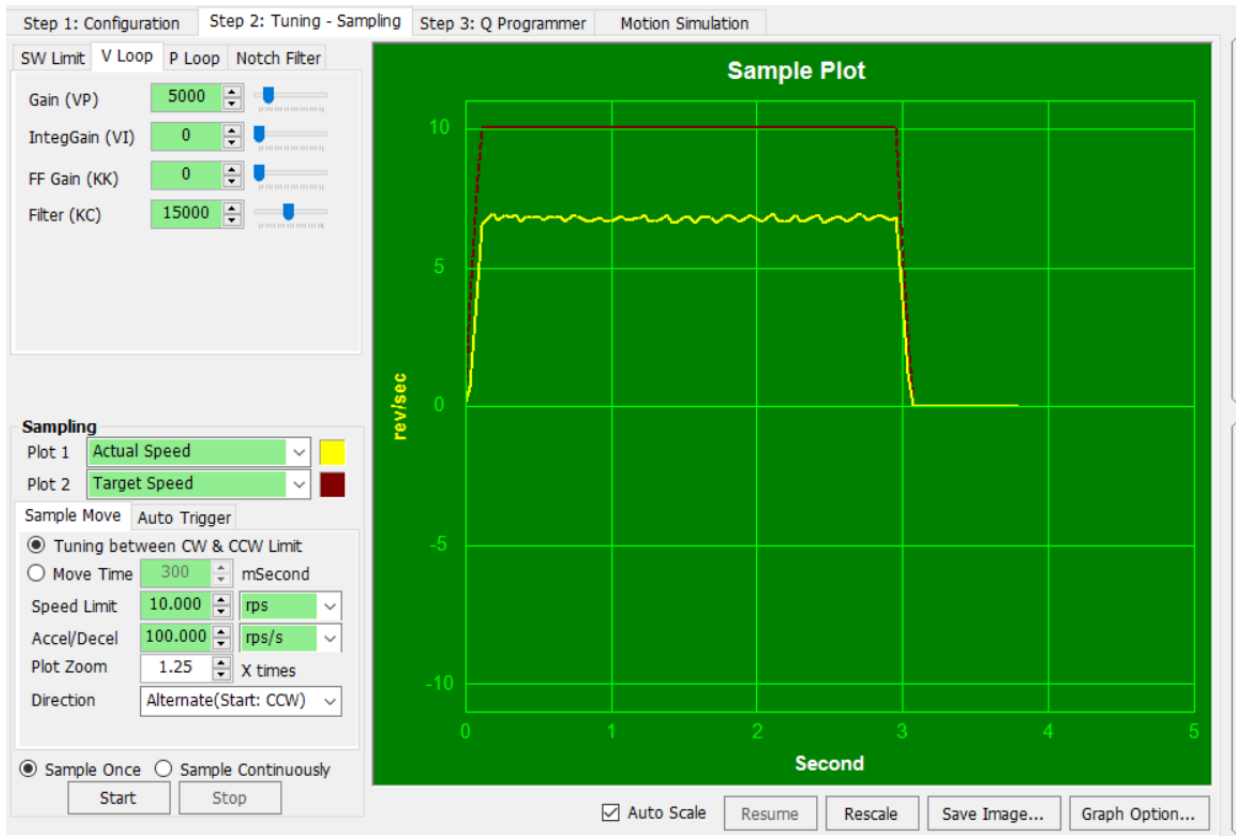


VP3000

24VDC

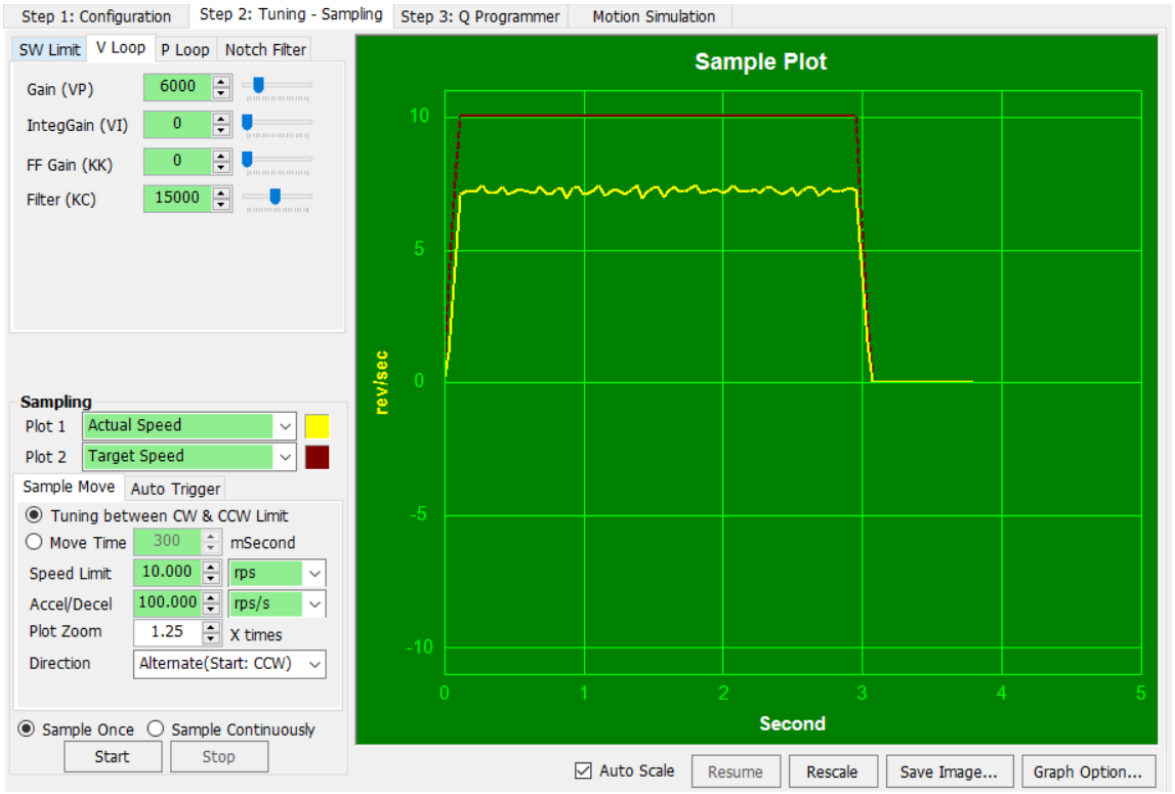


VP4000

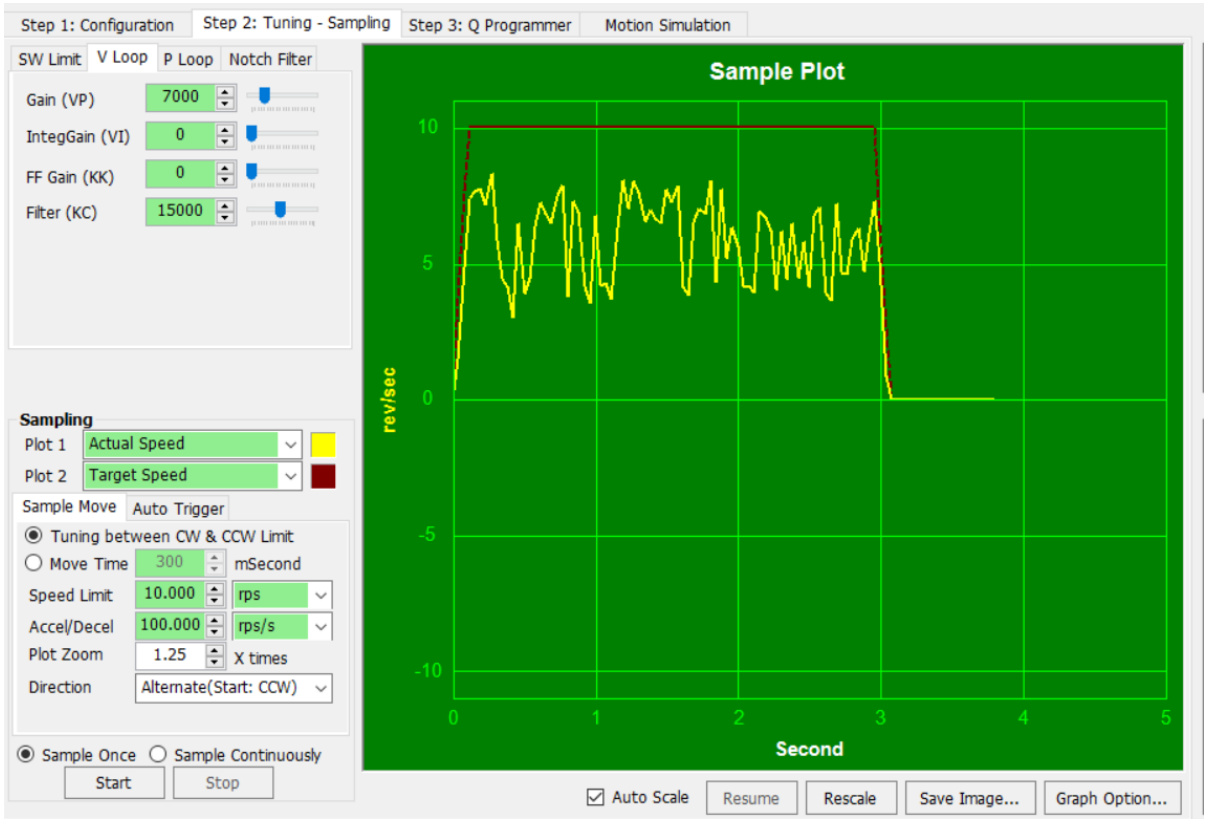


VP5000

24VDC

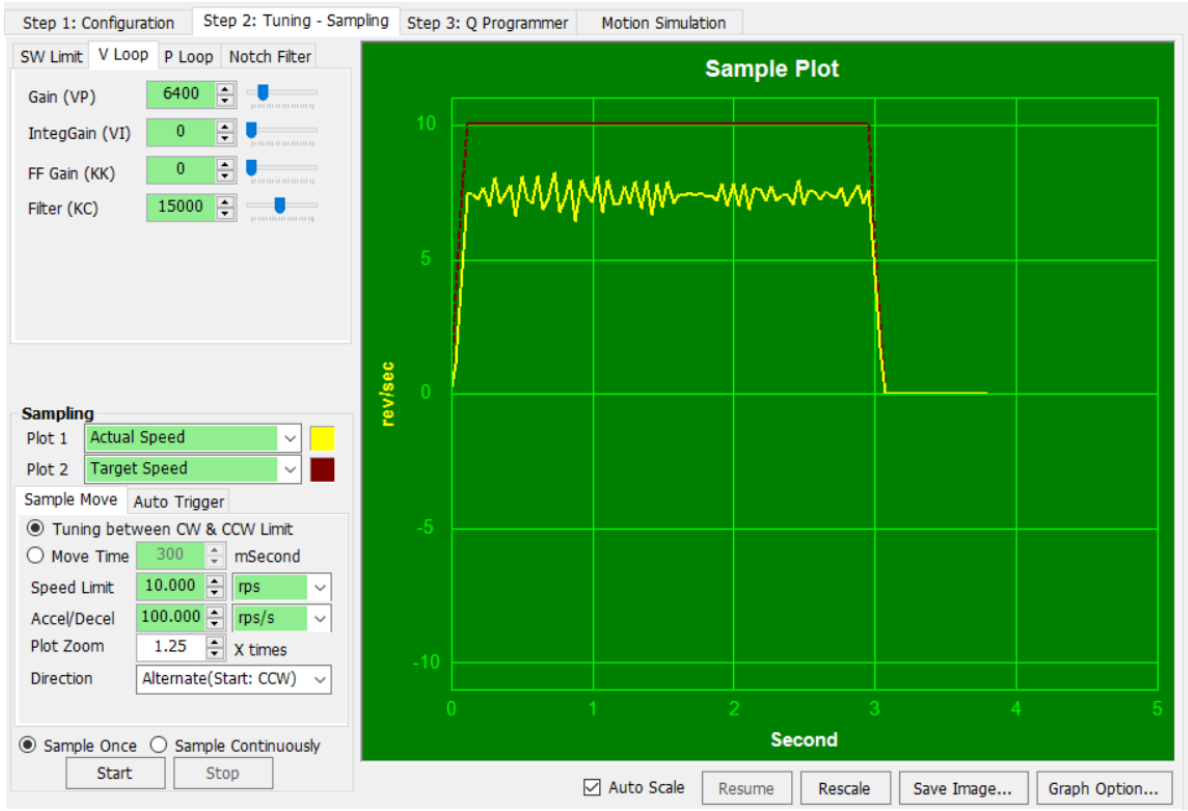


VP6000

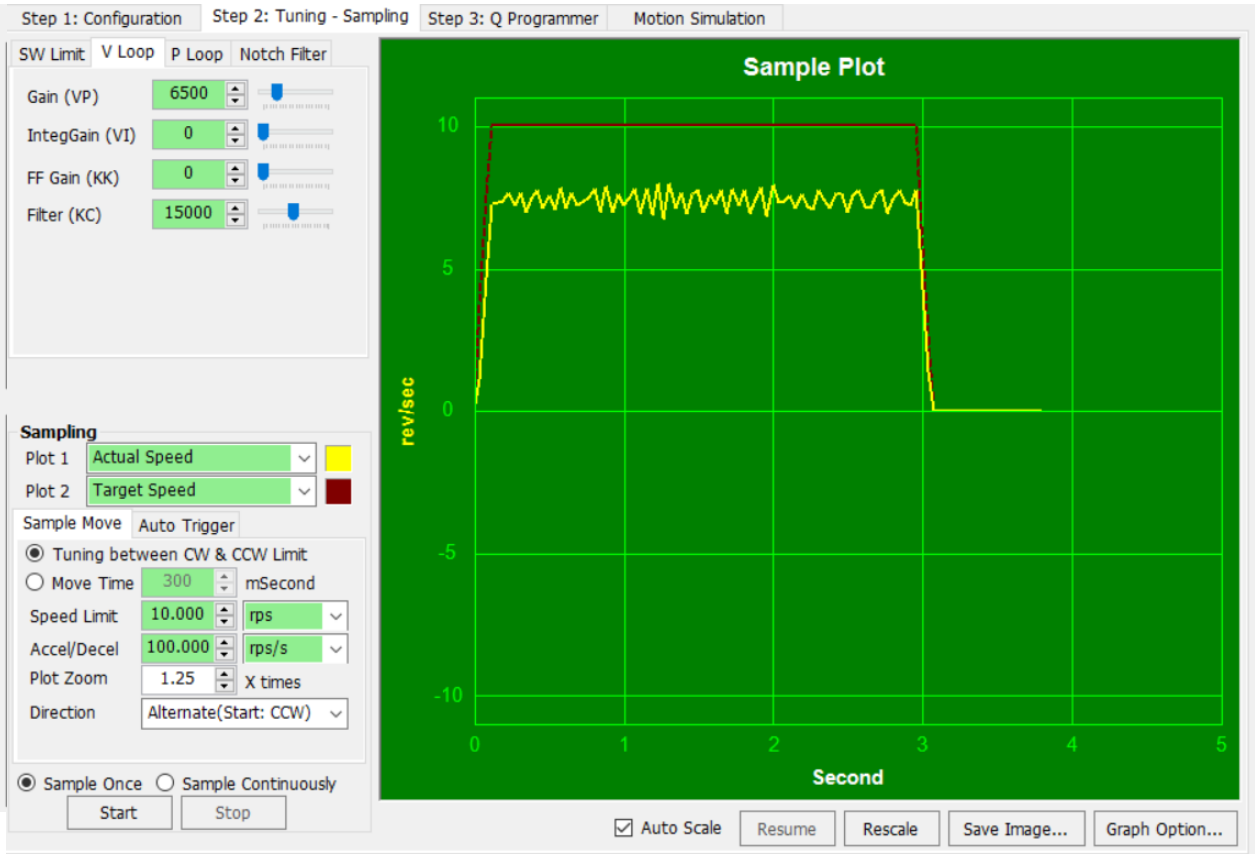


VP7000 有噪音

24VDC

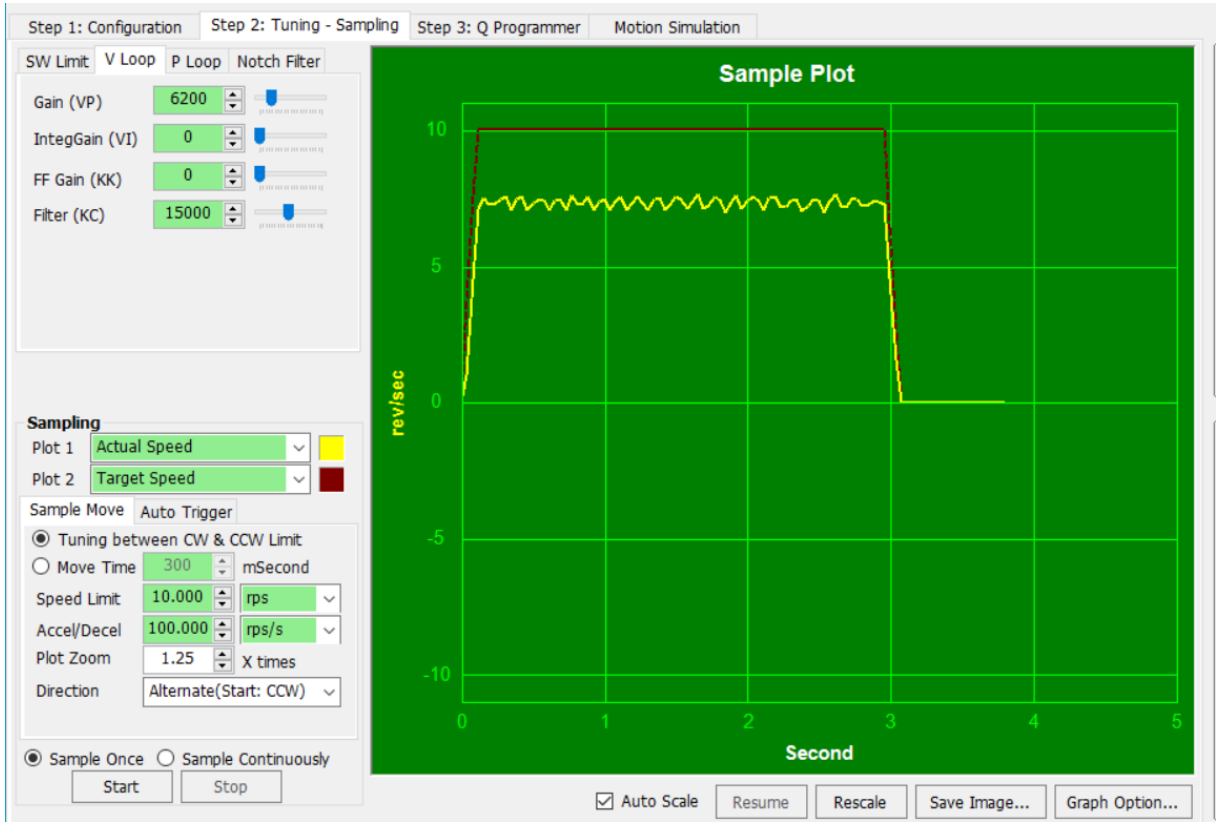


VP6400, 有噪音

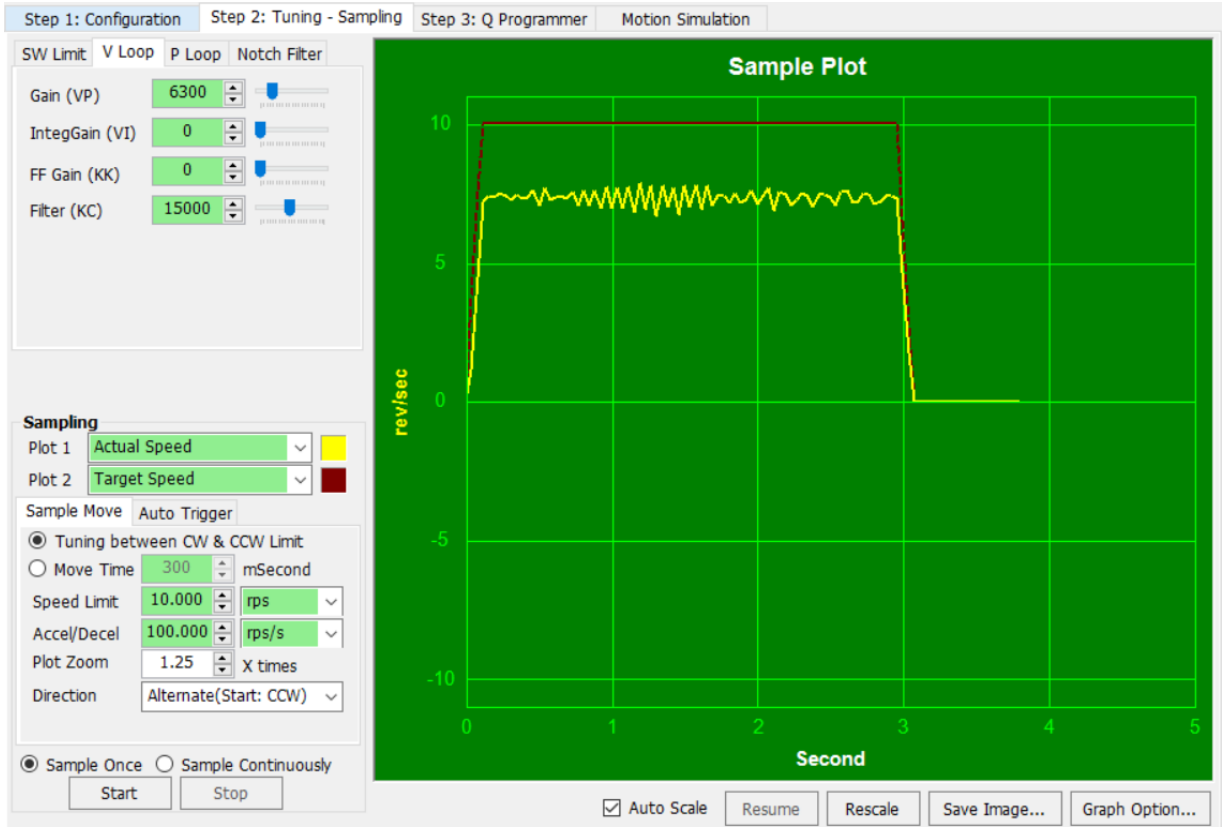


VP6500, 有噪音

24VDC

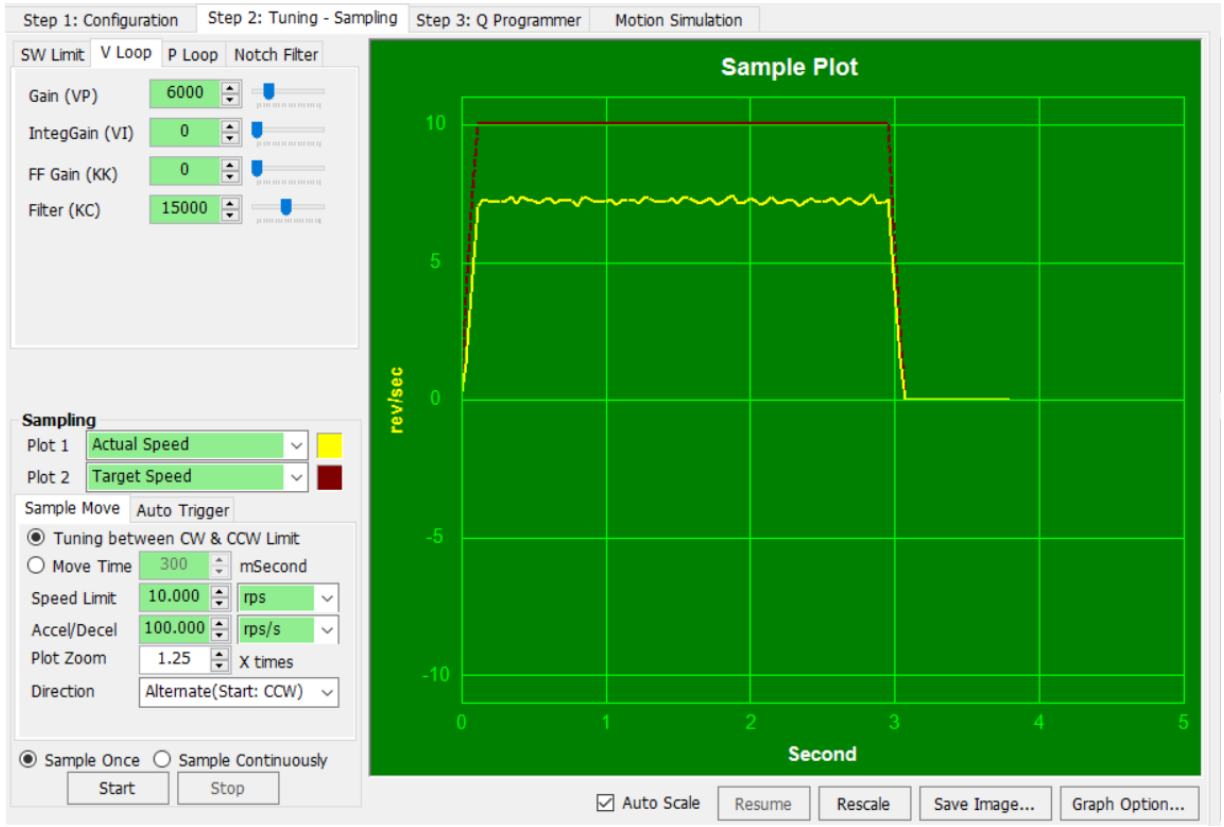


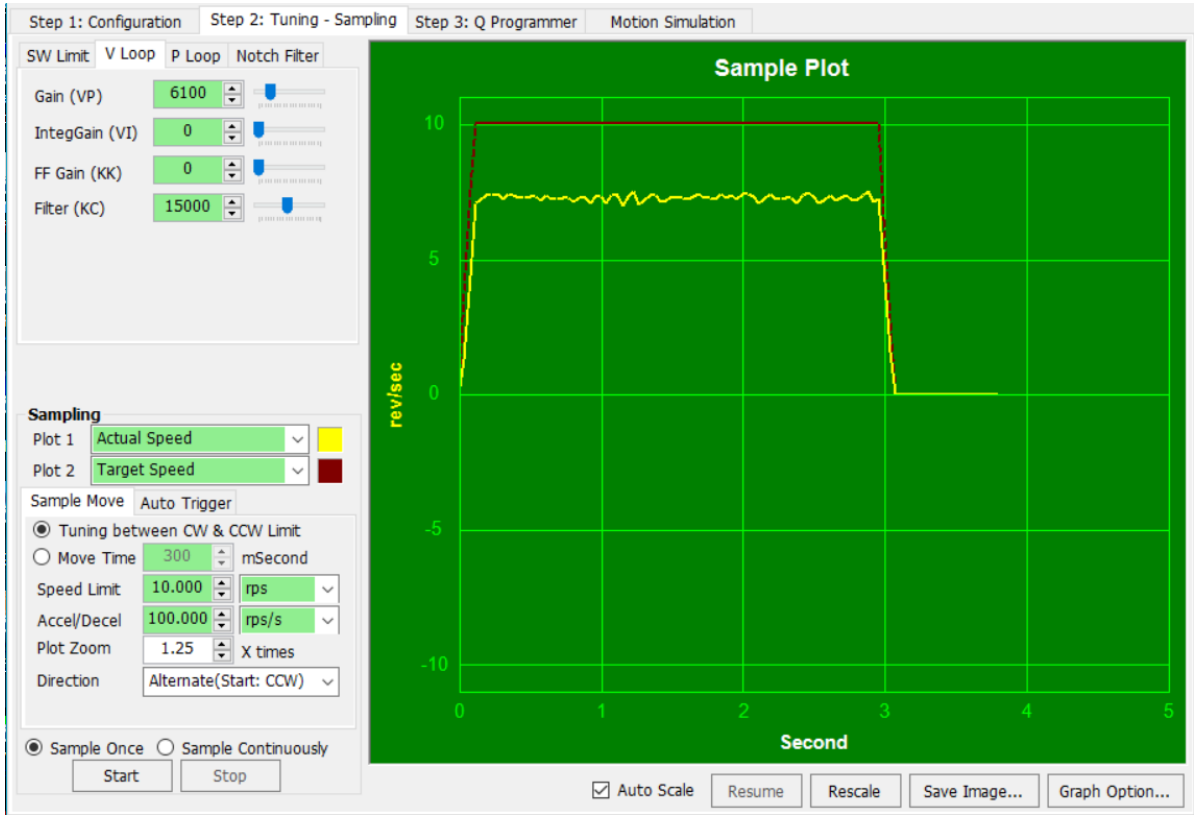
VP6200, 有噪音



VP6300, 有噪音

24VDC





VP6000 較無噪音

VP6100, 有噪音

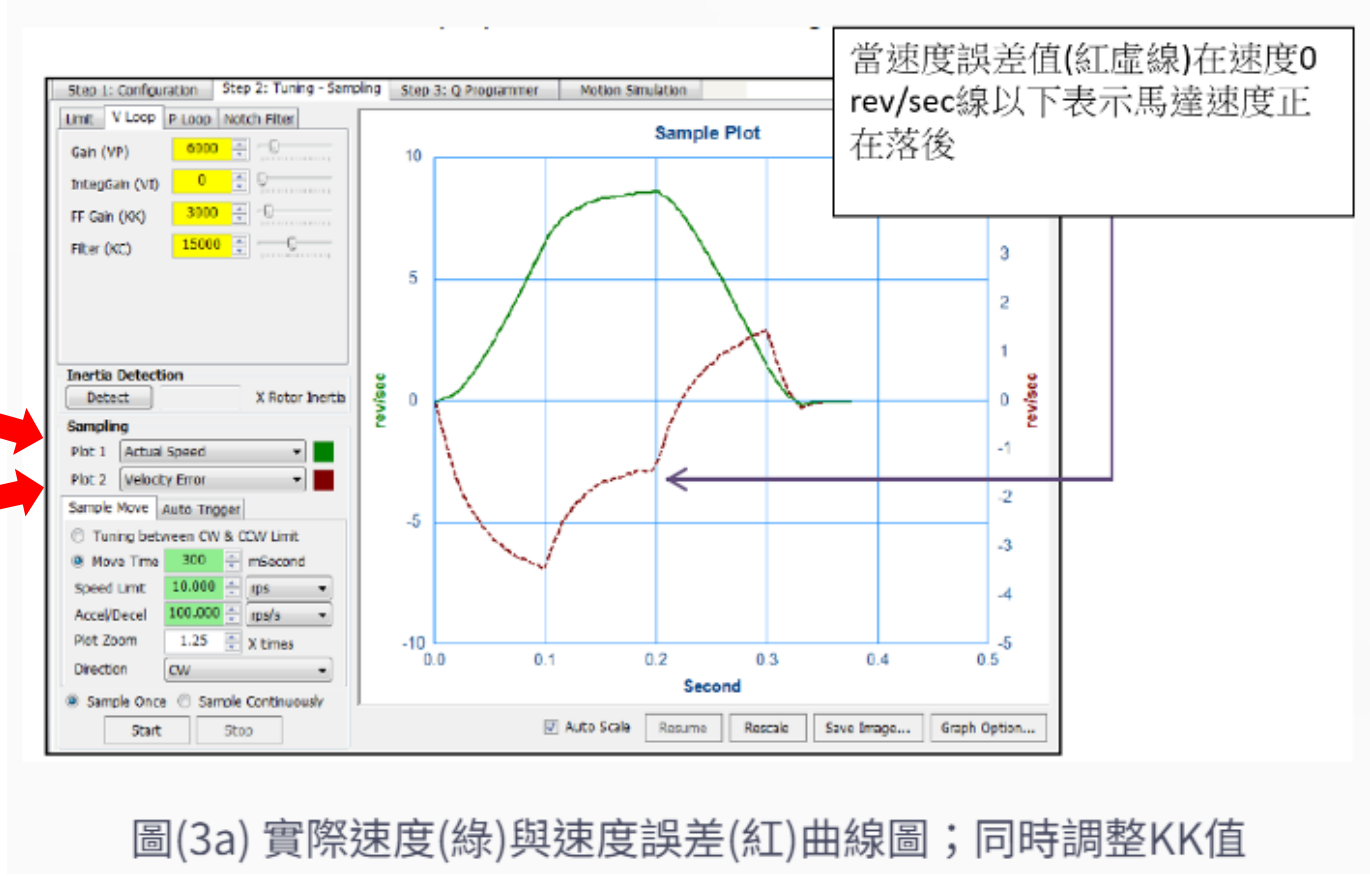
步驟三：繪製速度誤差曲線以調整KK值與VI值

(1) 將Plot 2設置為速度誤差，並勾選”自動縮放”(Auto Scale)選項

(2) 執行範例動作，同時先增加KK值，如圖(3a)

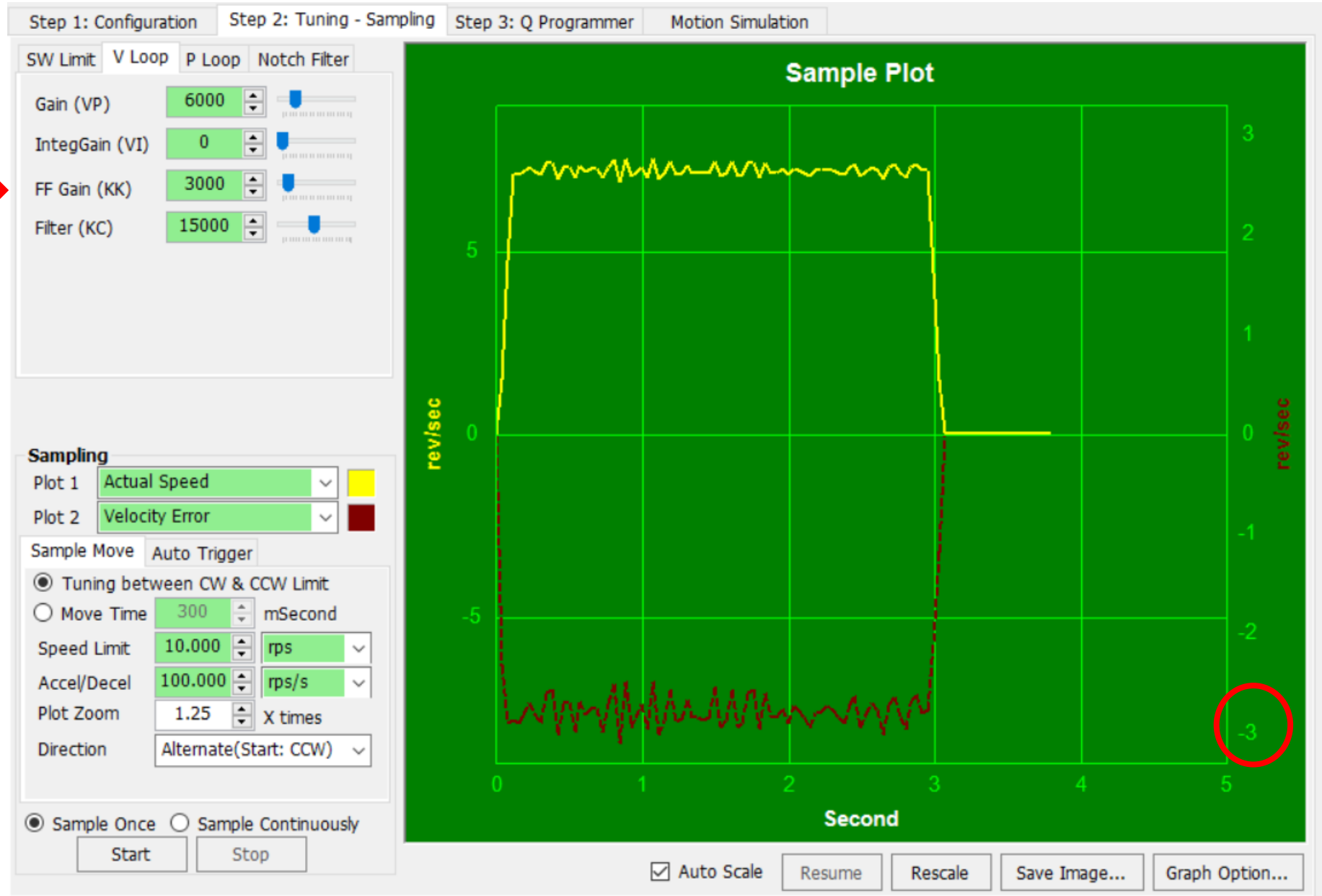
Plot 1:
Actual Speed

Plot 2:
Velocity Error



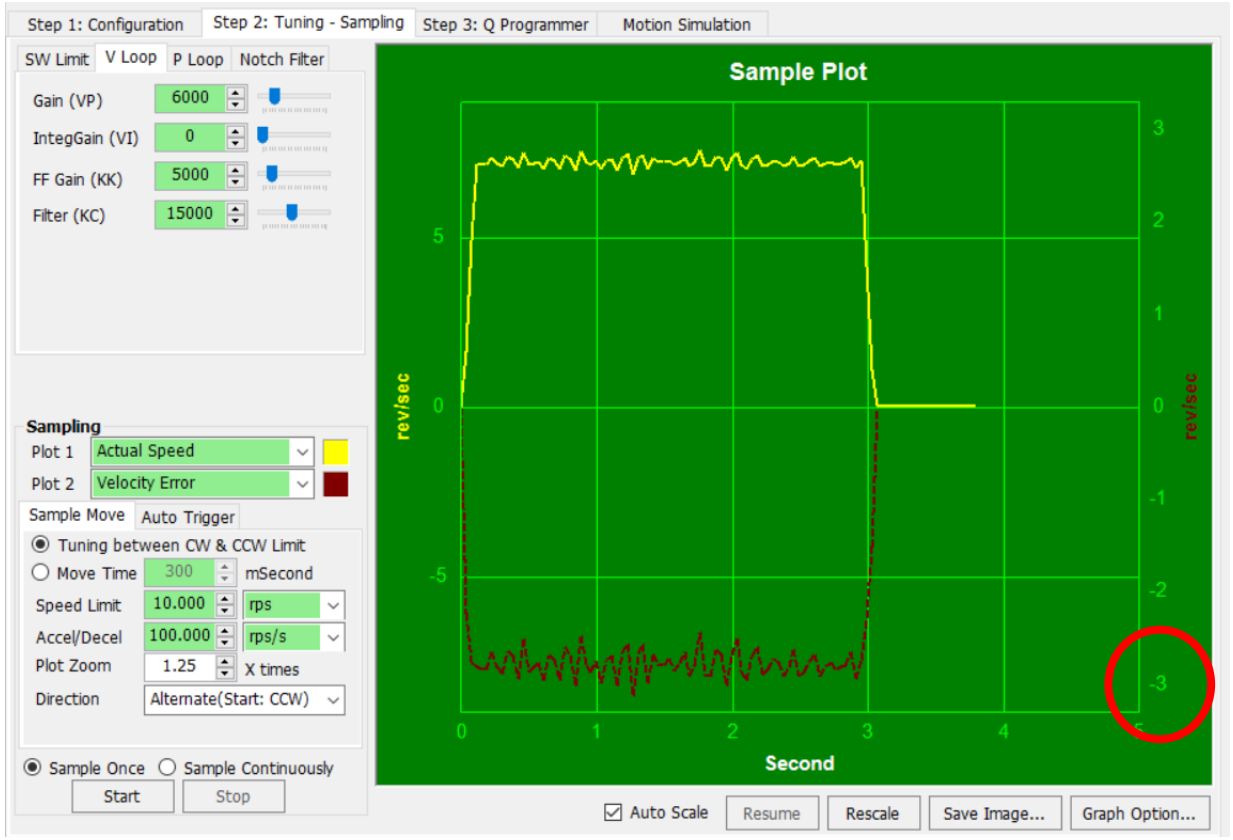
圖(3a) 實際速度(綠)與速度誤差(紅)曲線圖；同時調整KK值

24VDC

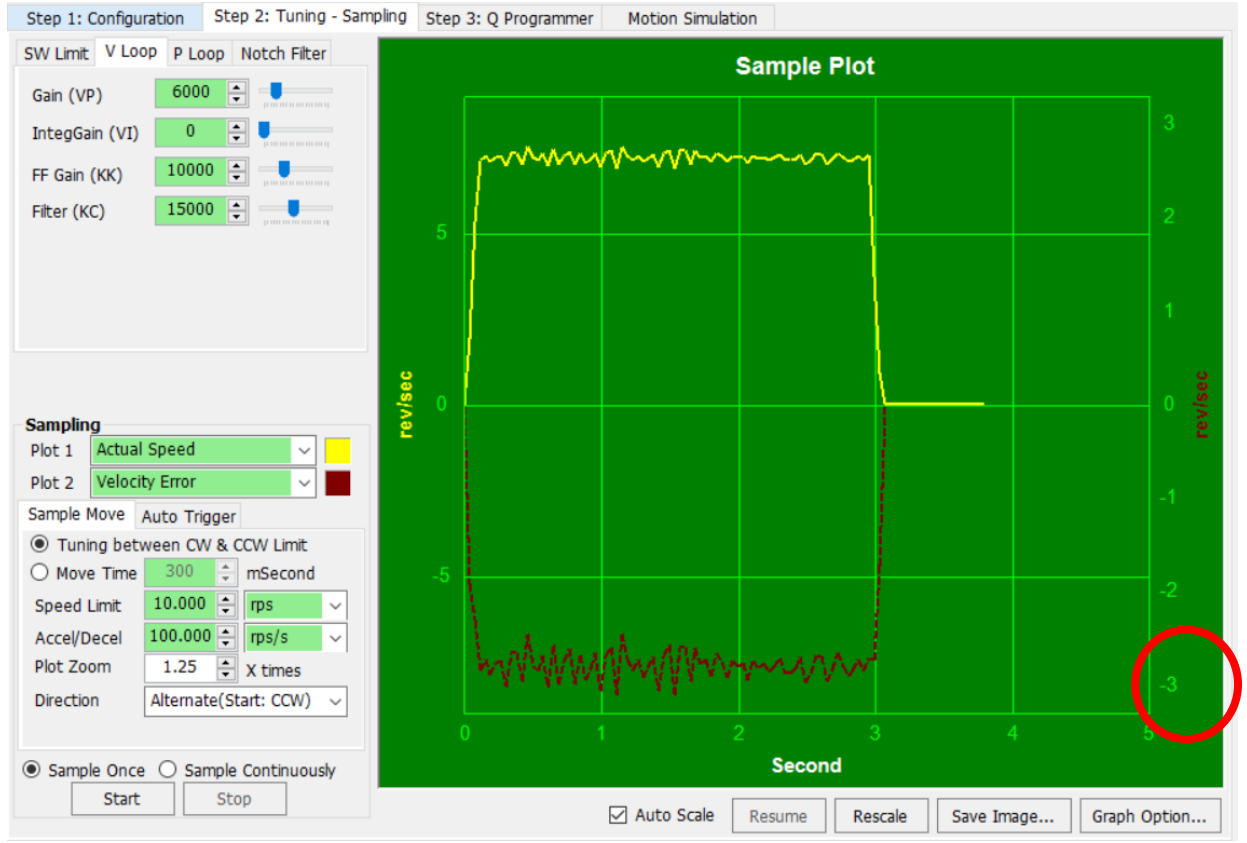


KK3000 / VI0

24VDC



KK5000 / VI0

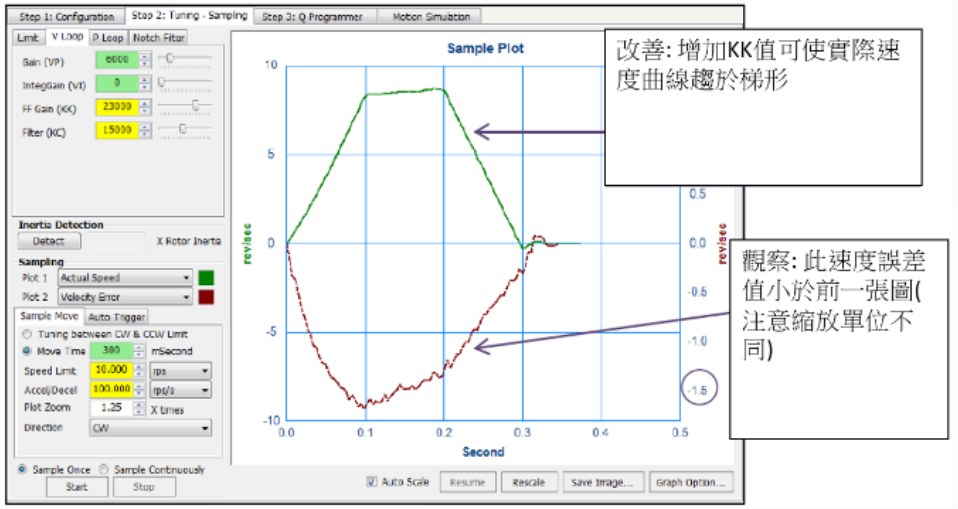


KK10000 / VI0

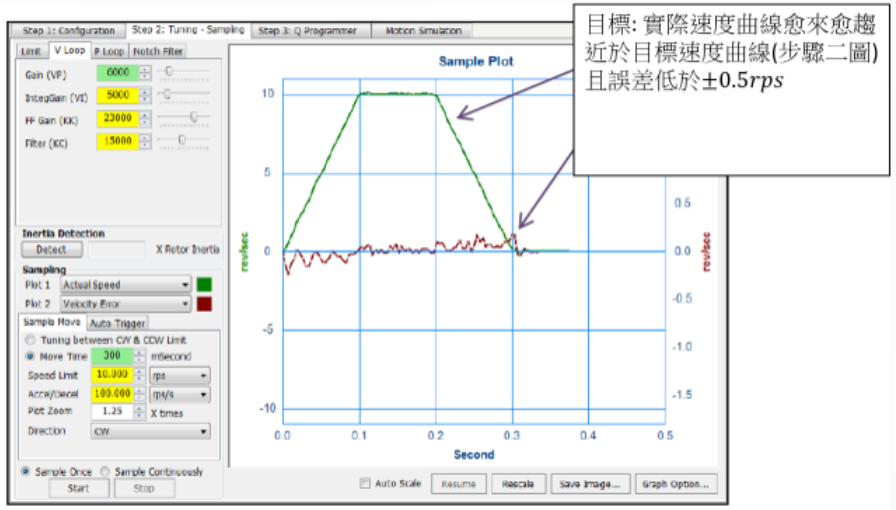
(3) 當實際速度曲線開始變尖時，然後開始逐漸增加VI值和KK值，以最大程度地減小和穩定速度誤差，如圖(3b)和(3c)

(i) 取消勾選”自動縮放”(Auto Scale)選項，將單位鎖定在垂直軸上；這有助於從視覺上看到速度誤差的減少

(ii)如果馬達開始發出噪音，降低KC值

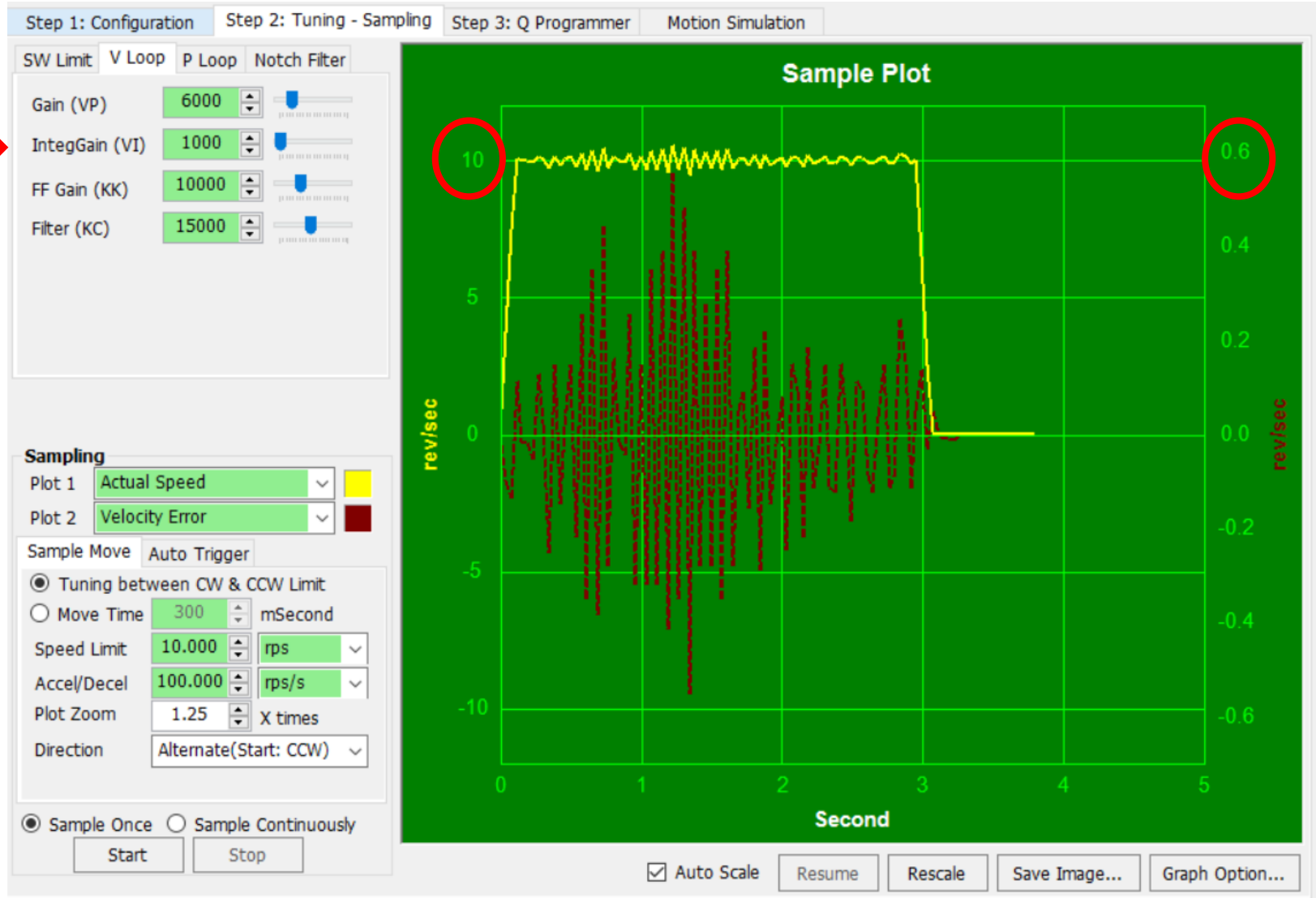


圖(3b) 隨著KK值增加，實際速度曲線輪廓愈來愈趨近於梯形



圖(3c) 隨著VI值與KK值的調整，使速度誤差趨於最小化

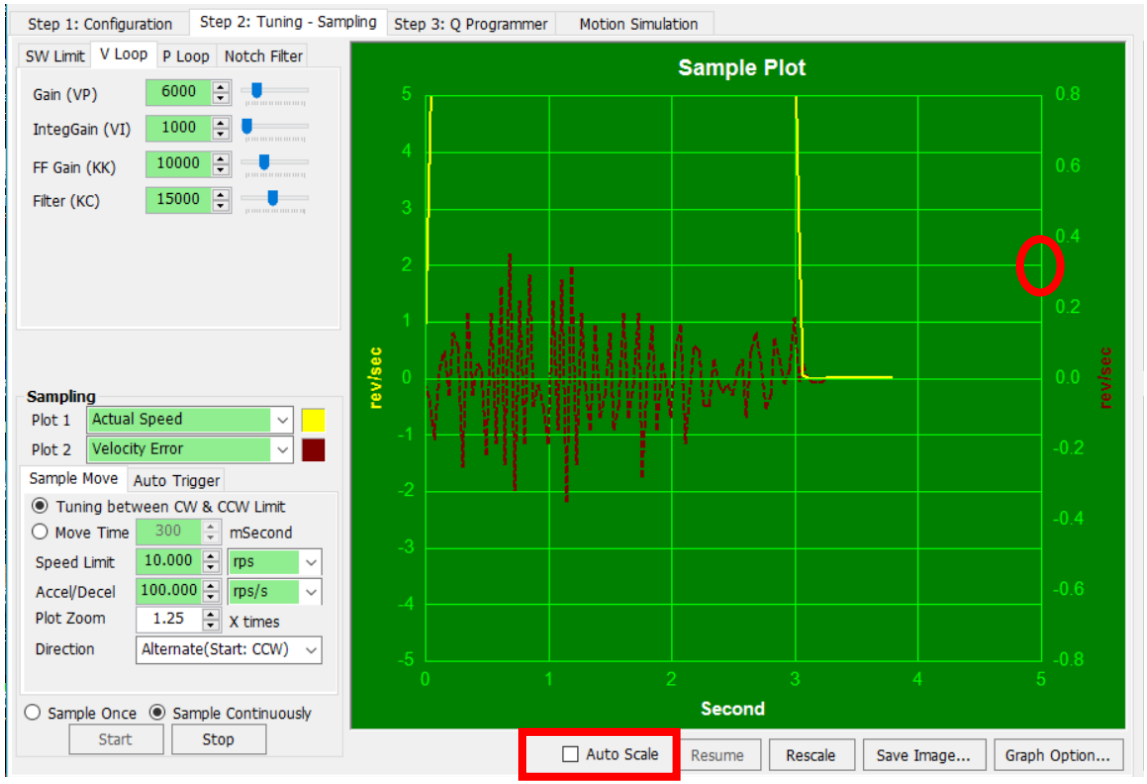
24VDC

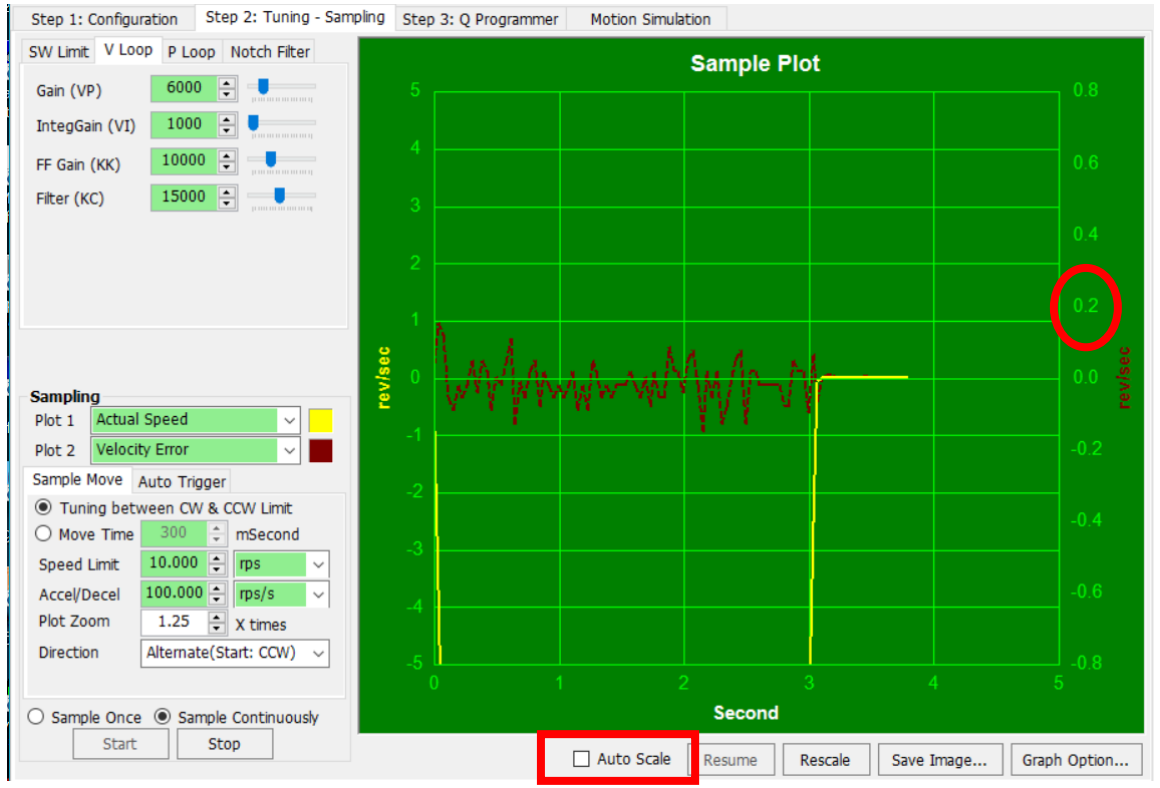


KK10000 / VI1000

24VDC

Auto Scale 取消，有助於從視覺上看到速度誤差的減少，誤差低於+/- 5rps



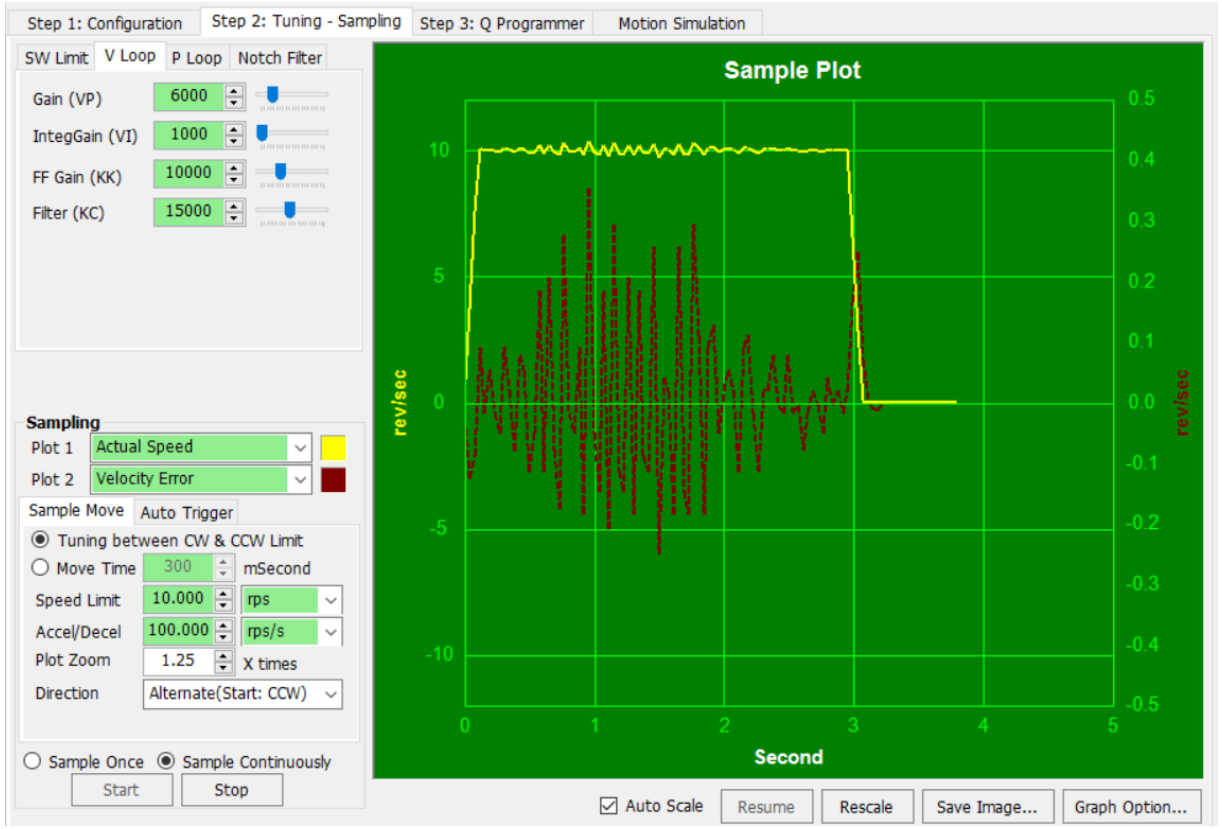


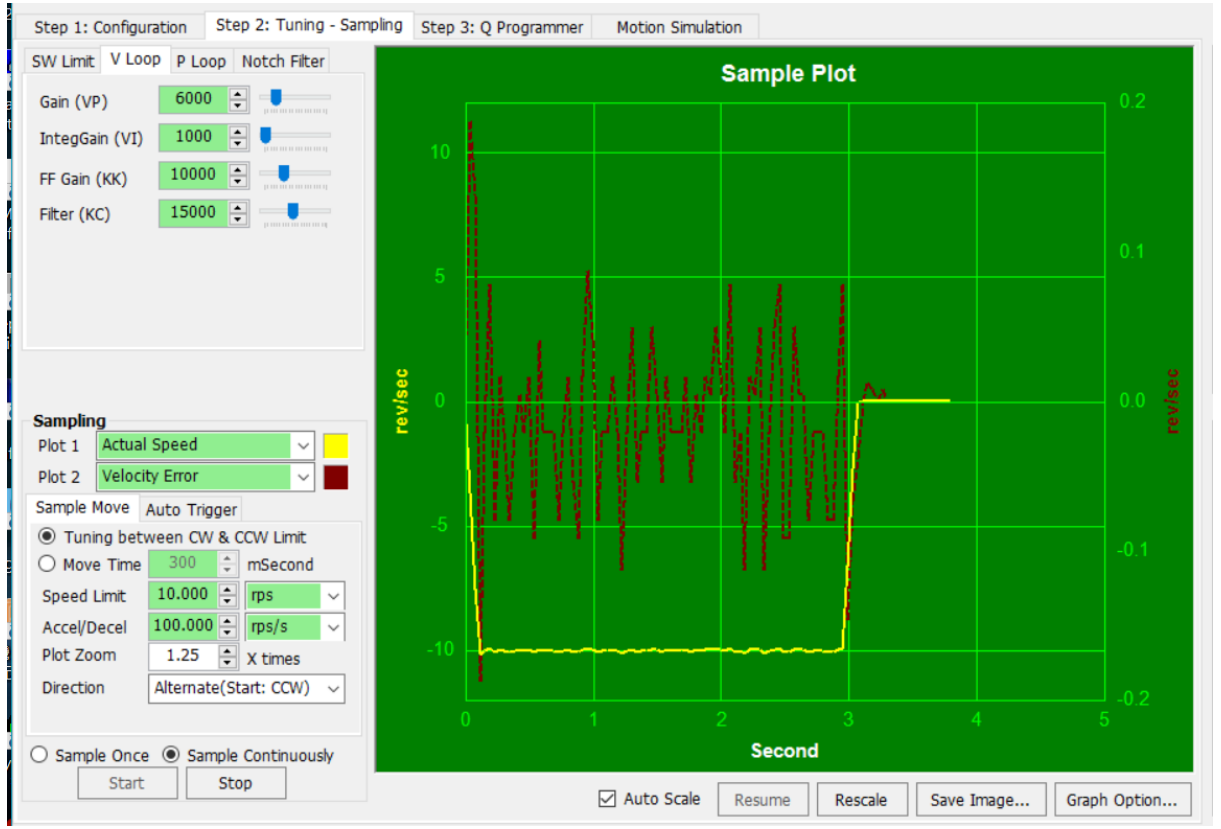
KK10000 / VI1000

24VDC

紀錄: 此時有些微噪音，降低KC值至14000時，噪音聲變大; KC16000時與KC15000時差別不大
VI2000 且其餘不變時，噪音加大
KK11000 且其餘不變時，噪音和速度誤差與KK10000時差別不大

Auto Scale 打勾





KK10000 / VI1000 / KC15000

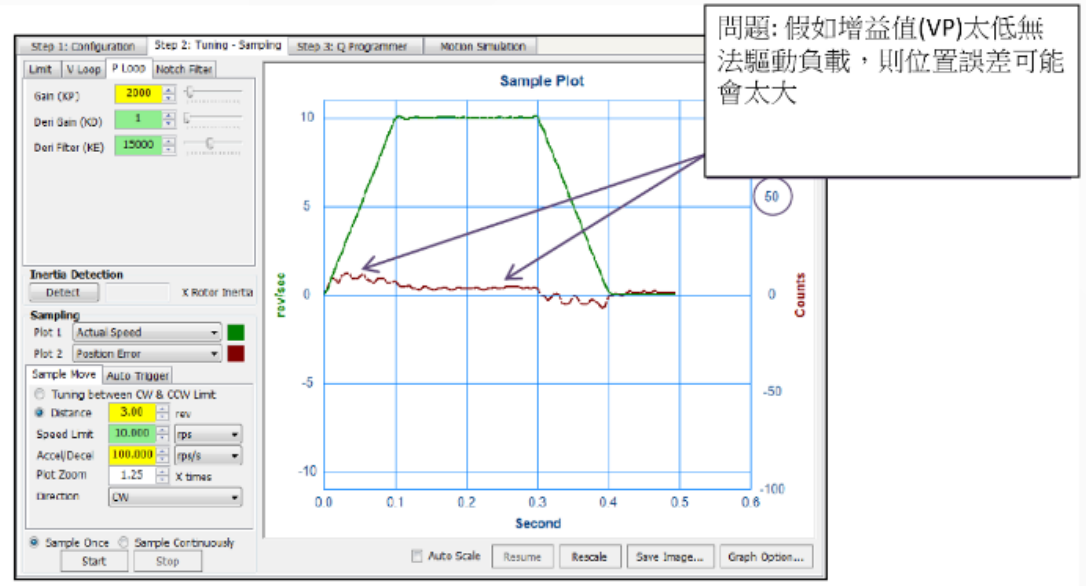
以下步驟為調整**位置環**。

步驟四：切換至P Loop(位置環)介面，並將Plot 2改為位置誤差

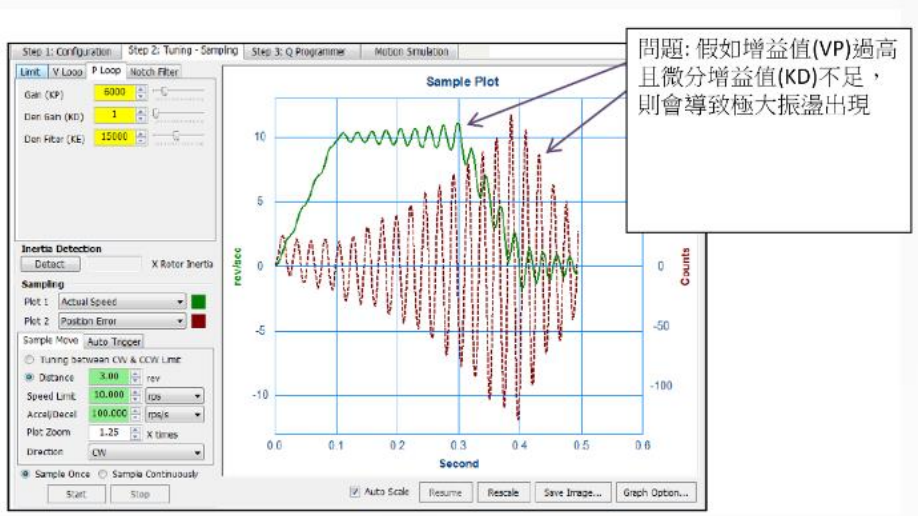
(1) 設置與V Loop(速度環)相似的範例動作

(2) 將KE值設為預設值15000，將KP值與KD值設為1

(3) 當執行範例動作時增加KP值，以最大程度地降低位置誤差，如圖(4a)。如過多增加KP值，可能導致不穩定，如圖(4b)。

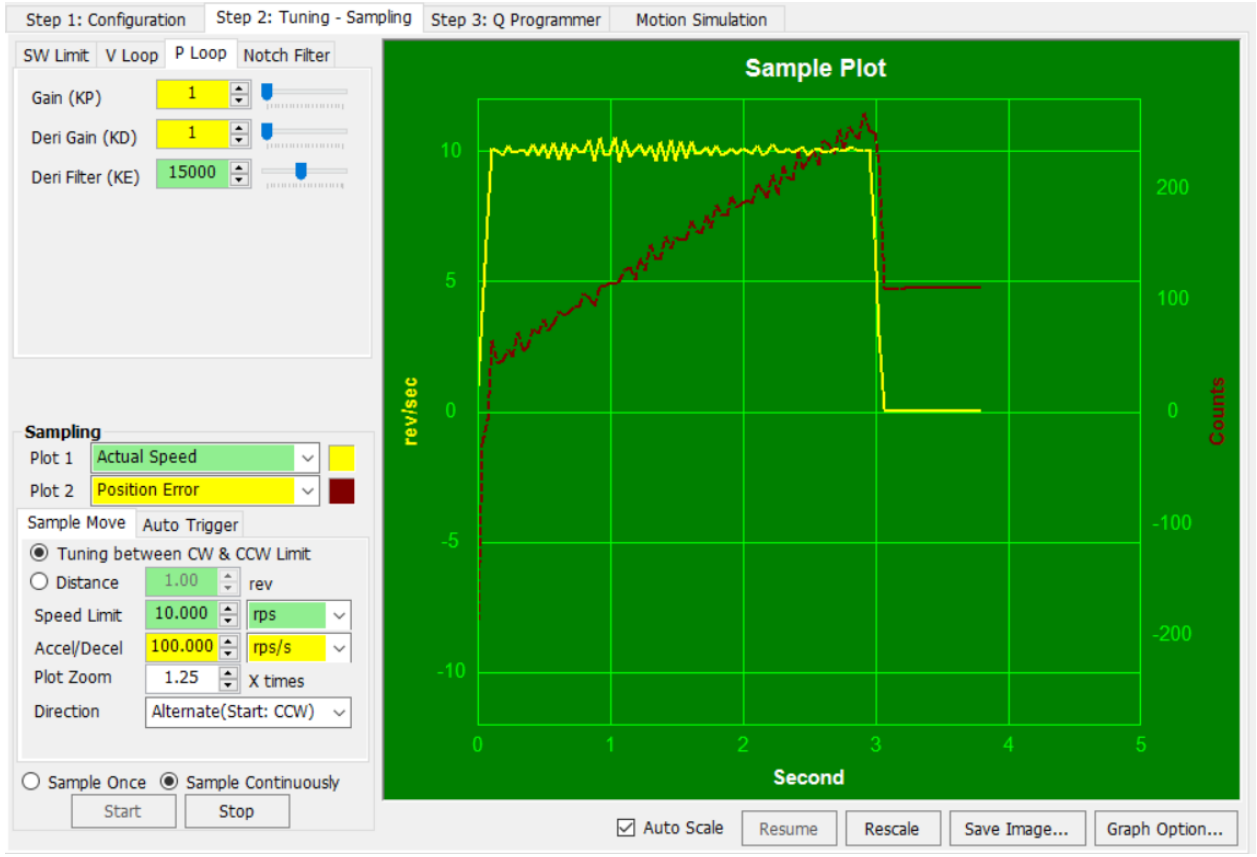


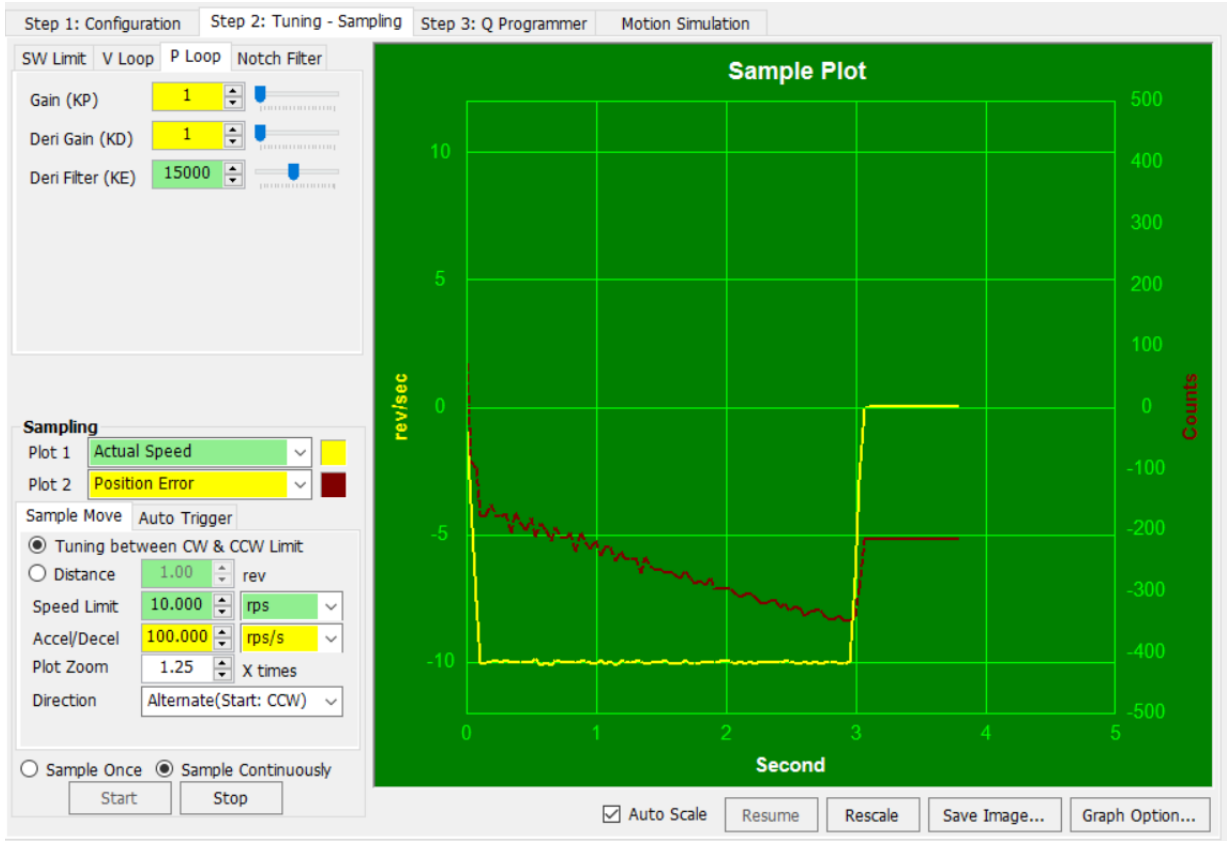
圖(4a) 位置環調整；實際速度與位置誤差曲線圖



圖(4b) 調整P Loop(位置環)時，過大的KP值所引起的不穩定

24VDC

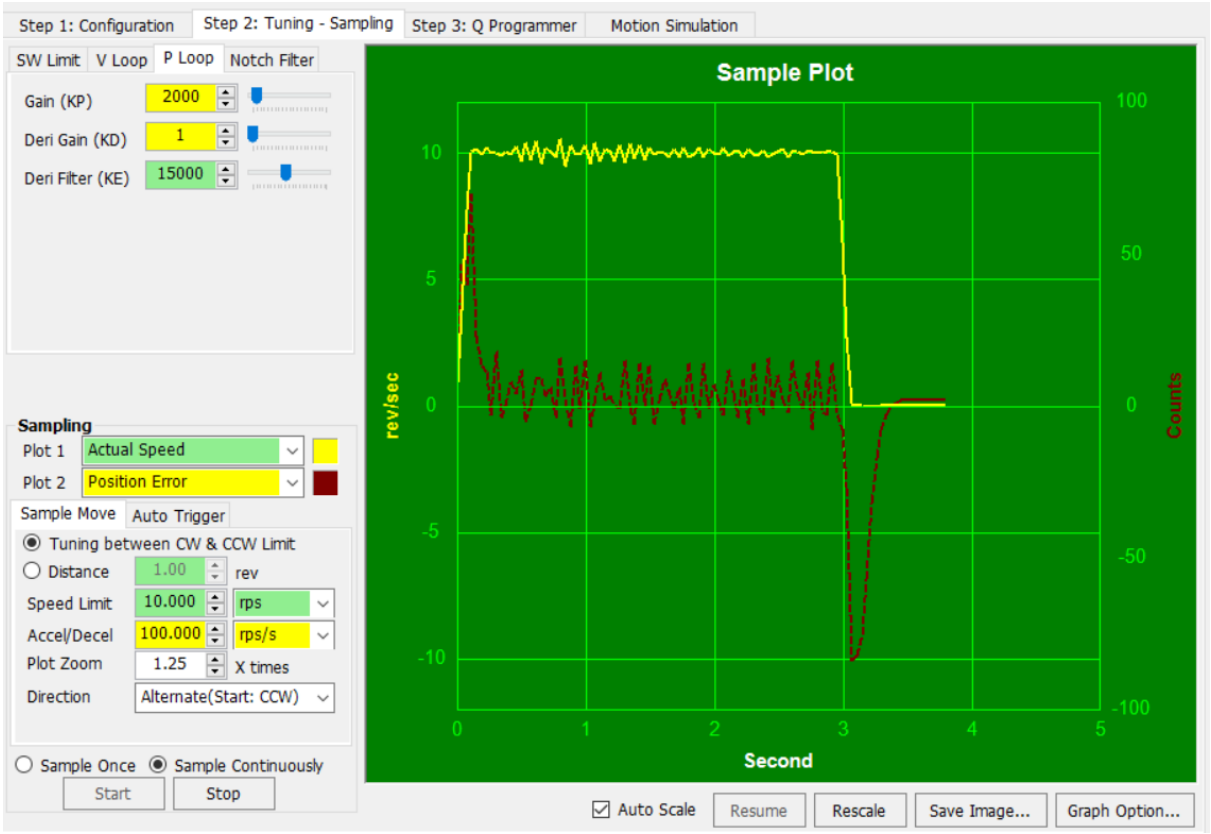


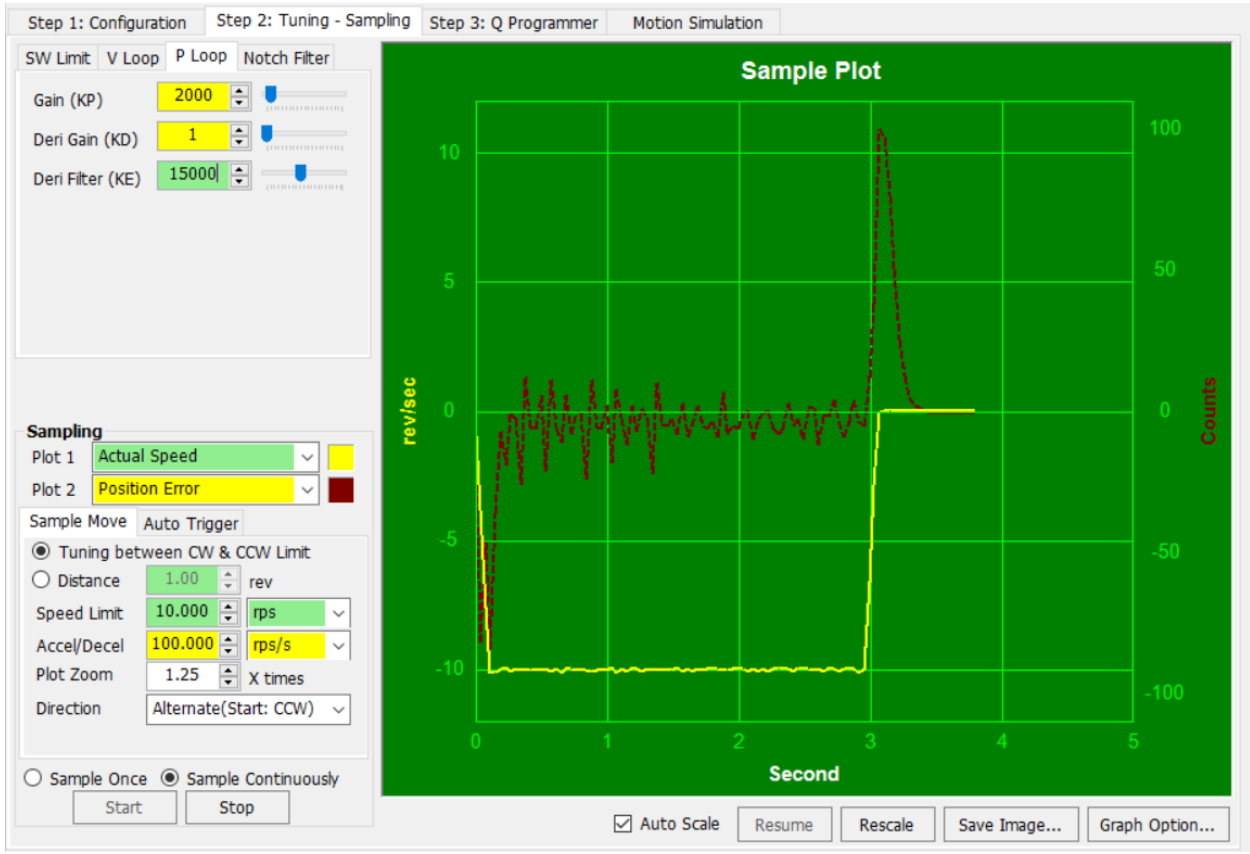


KP1 / KD1 / KE15000

24VDC

紀錄: KP0到KP2000, 噪音無增加, 位置誤差明顯減少

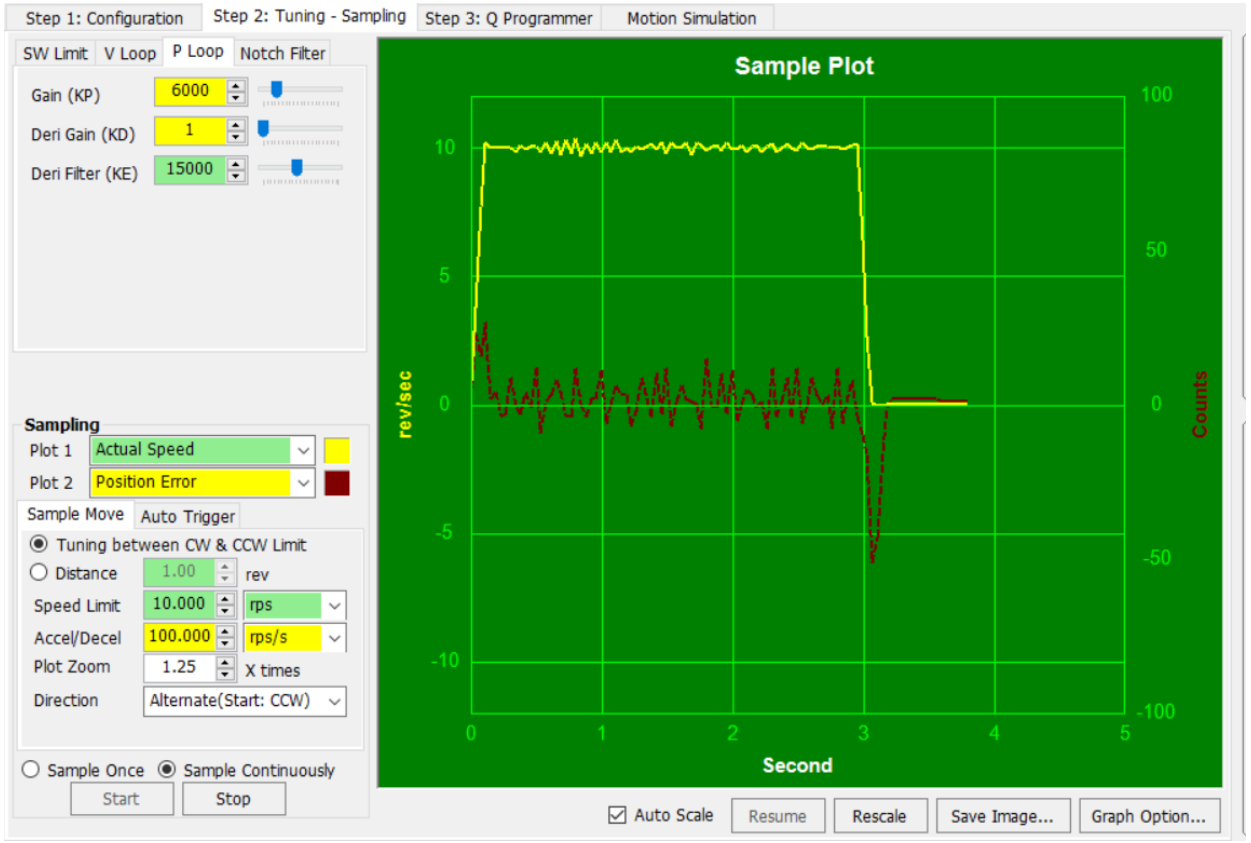


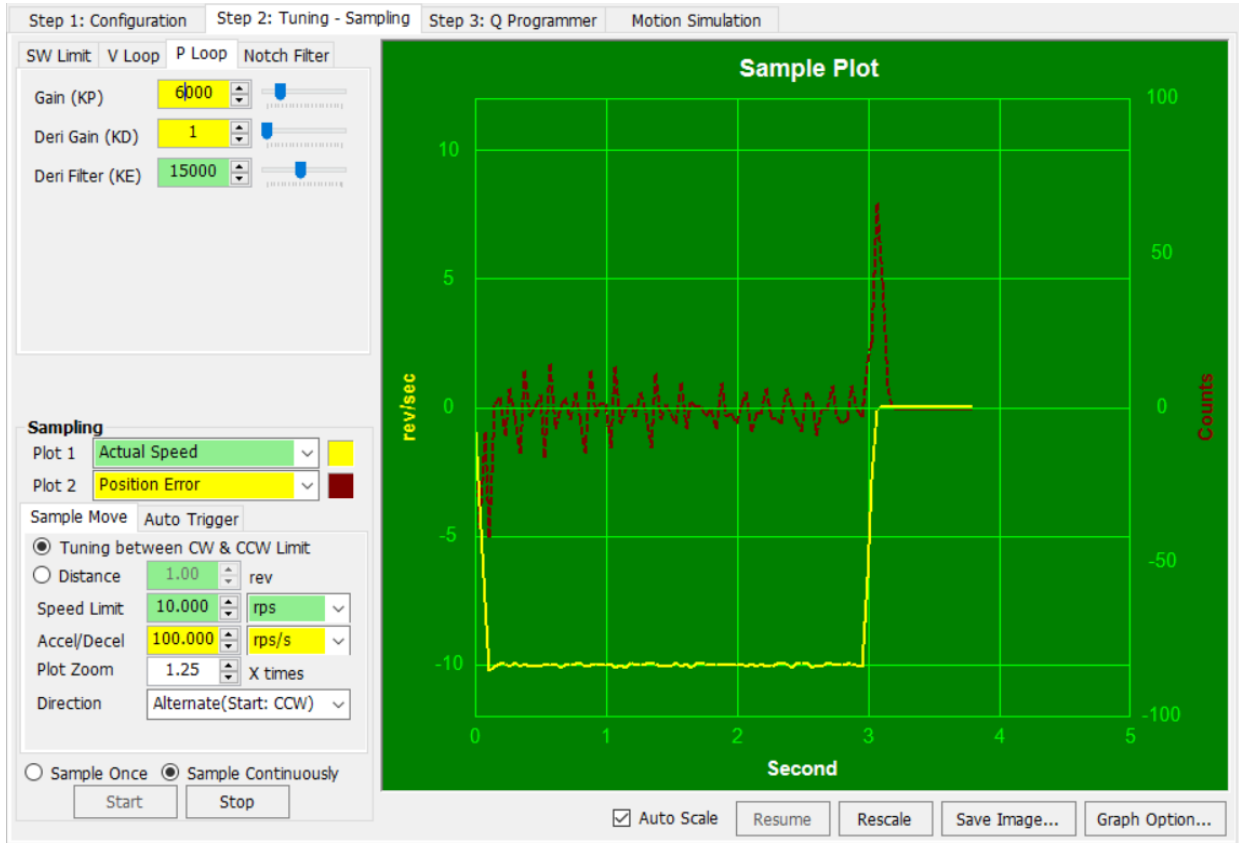


KP2000 / KD1 / KE15000

24VDC

紀錄: KP2000到KP6000, 噪音無增加, 位置誤差明顯減少

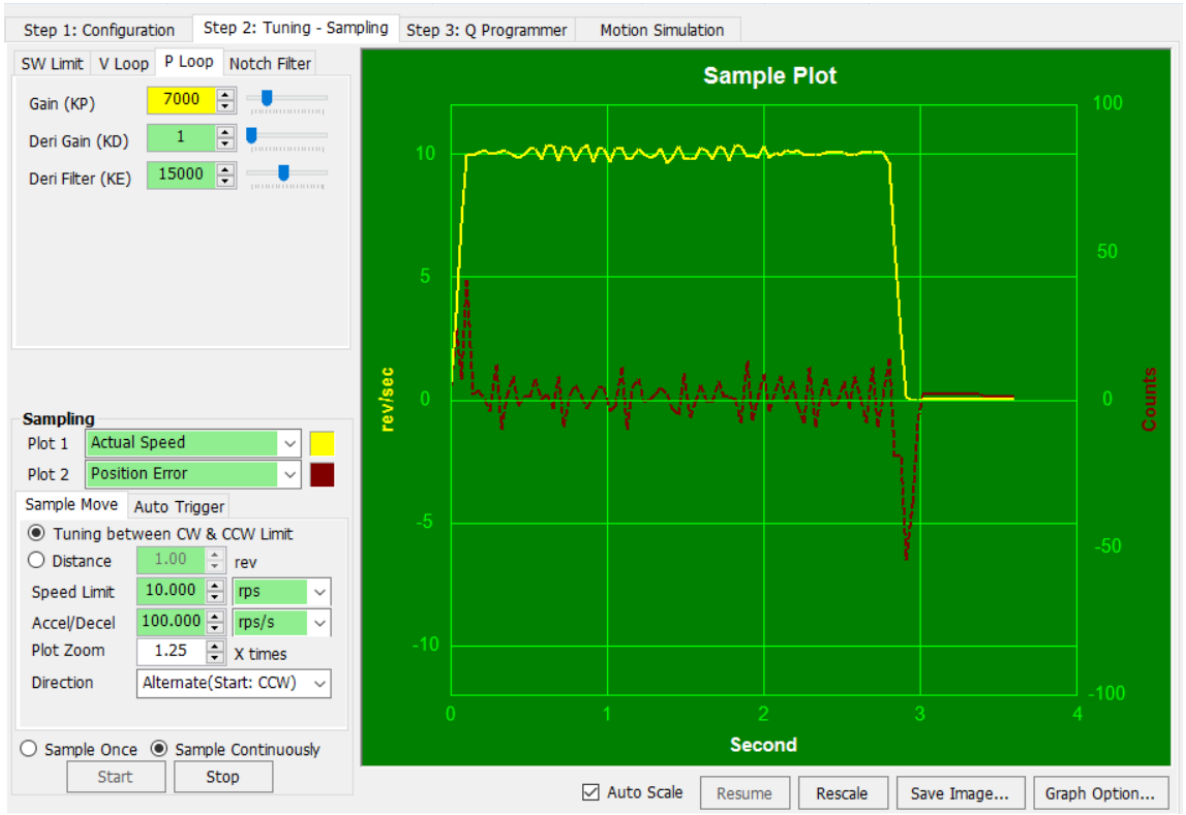


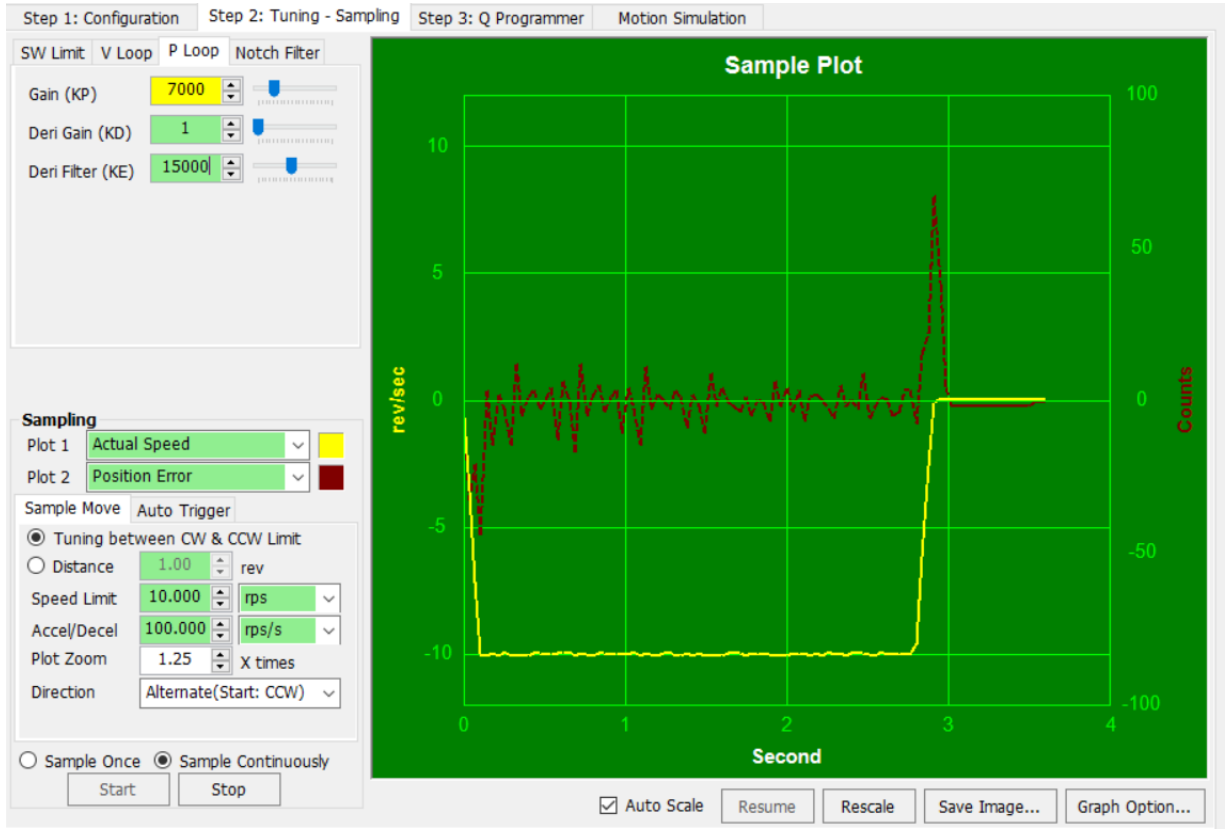


KP6000 / KD1 / KE15000

24VDC

紀錄: KP6000到KP7000, 噪音有增加一些, 位置誤差沒甚麼變化

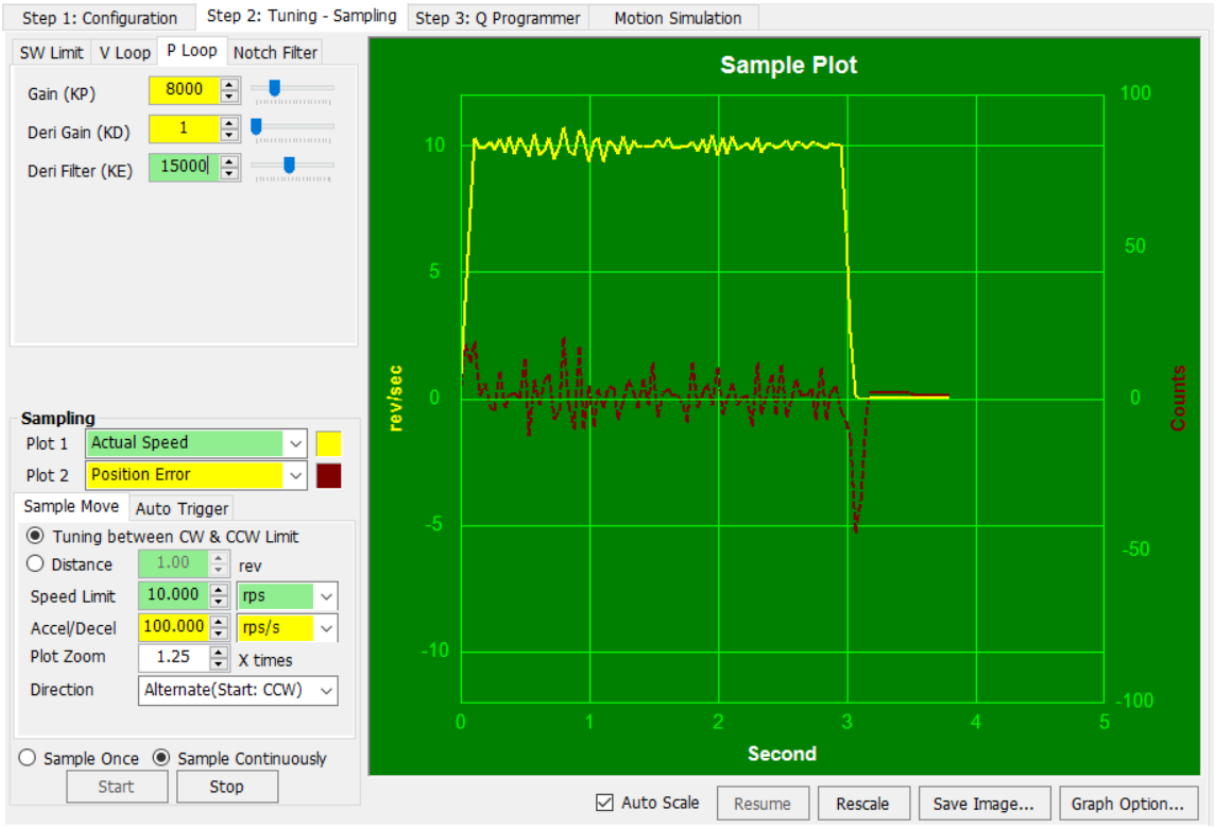


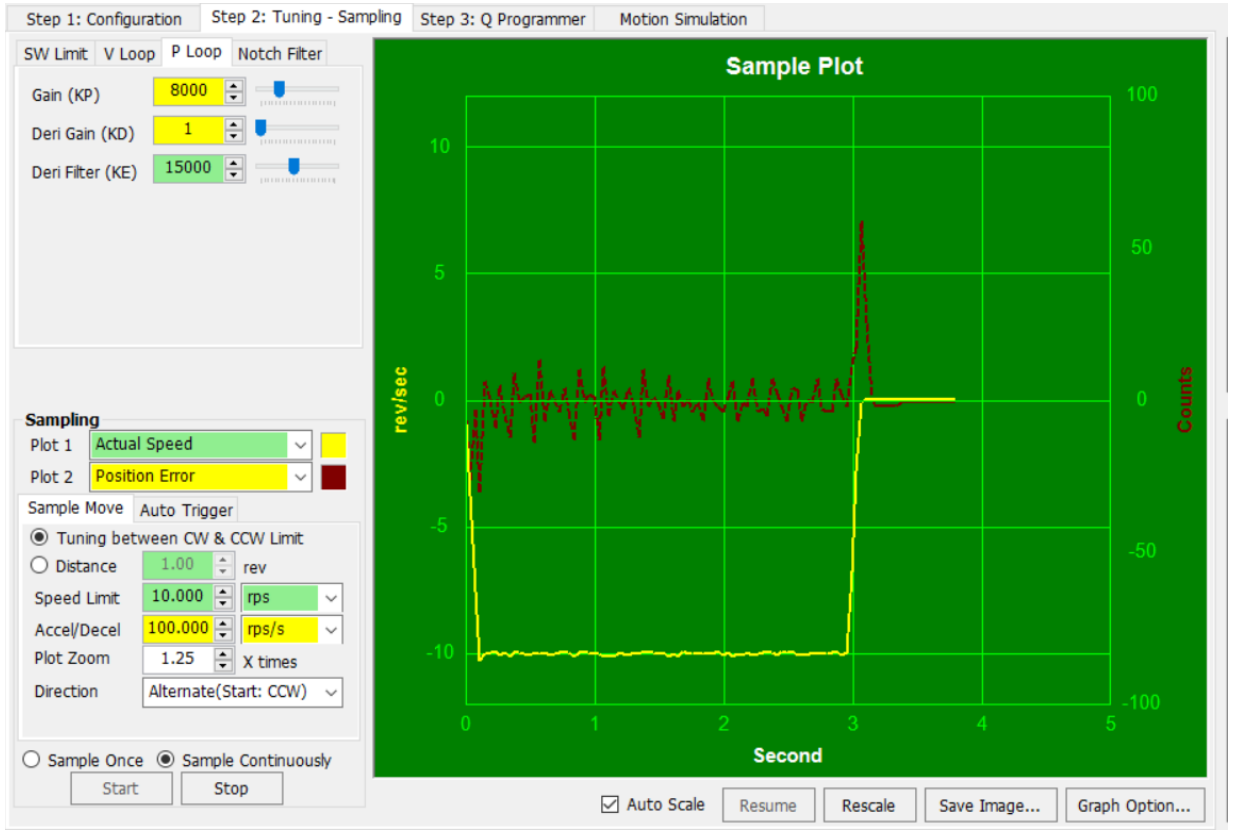


KP7000 / KD1 / KE15000

24VDC

紀錄: KP6000到KP8000, 噪音有增加一些, 位置誤差減少一些

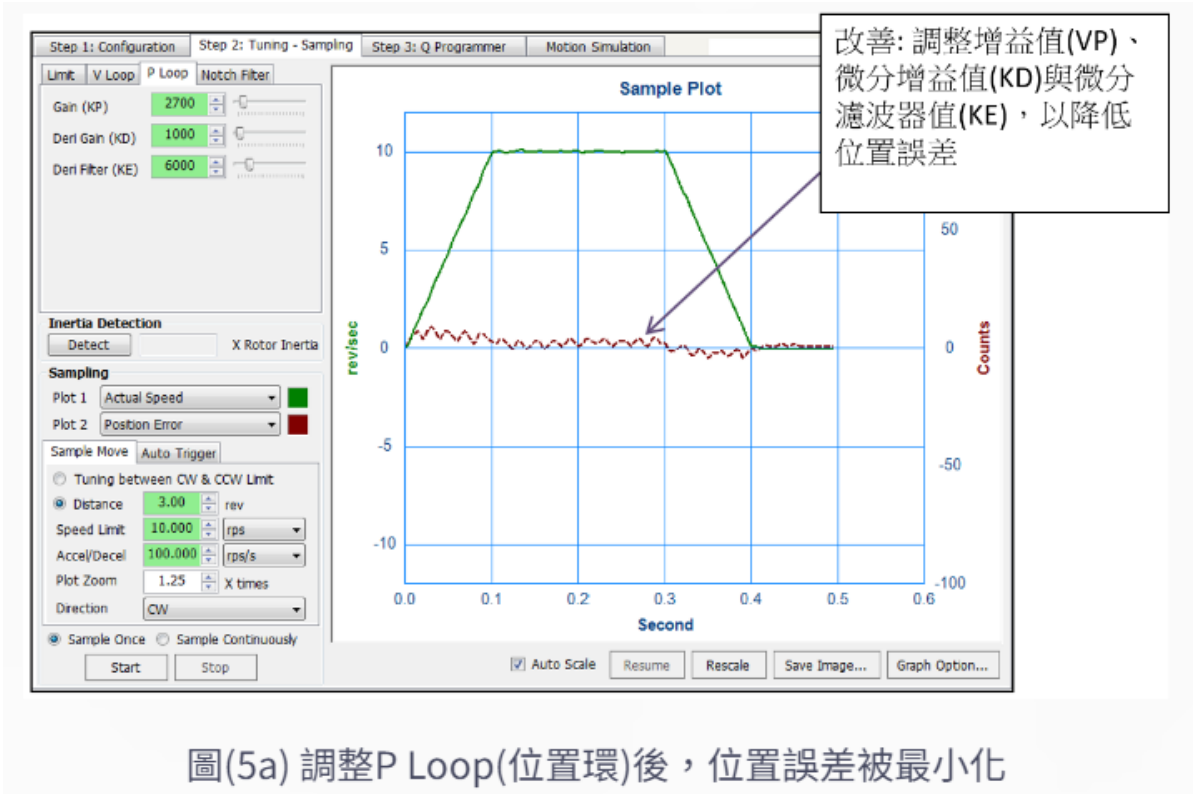




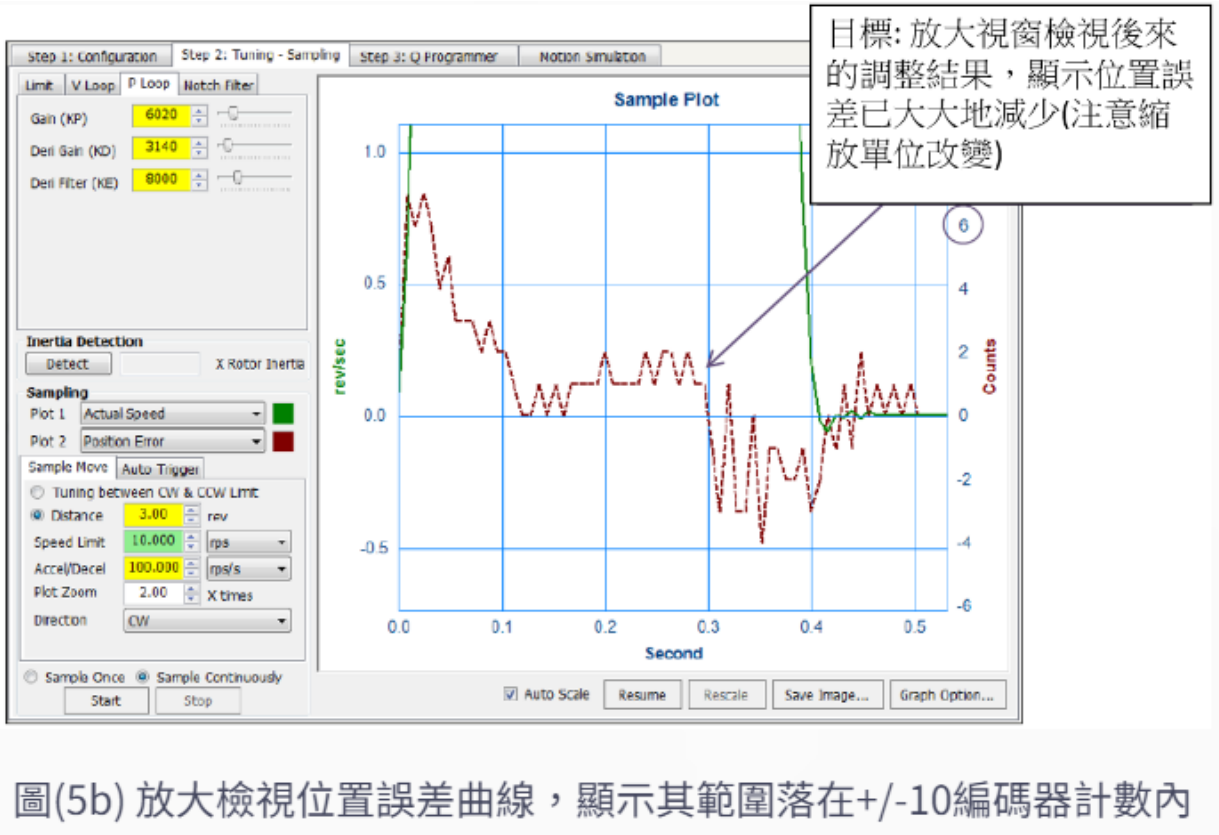
KP8000 / KD1 / KE15000

步驟五：增加KD值並調整KP與KE值，如圖(5a)

(1) 增加KD值的同時，繼續執行範例動作
(2) 如果聽見馬達發出尖銳噪音，則降低KE值
(3) 當位置誤差和建立時間滿足要求時，調整完成
(4) 用滑鼠游標放大檢視位置誤差，如圖(5b)

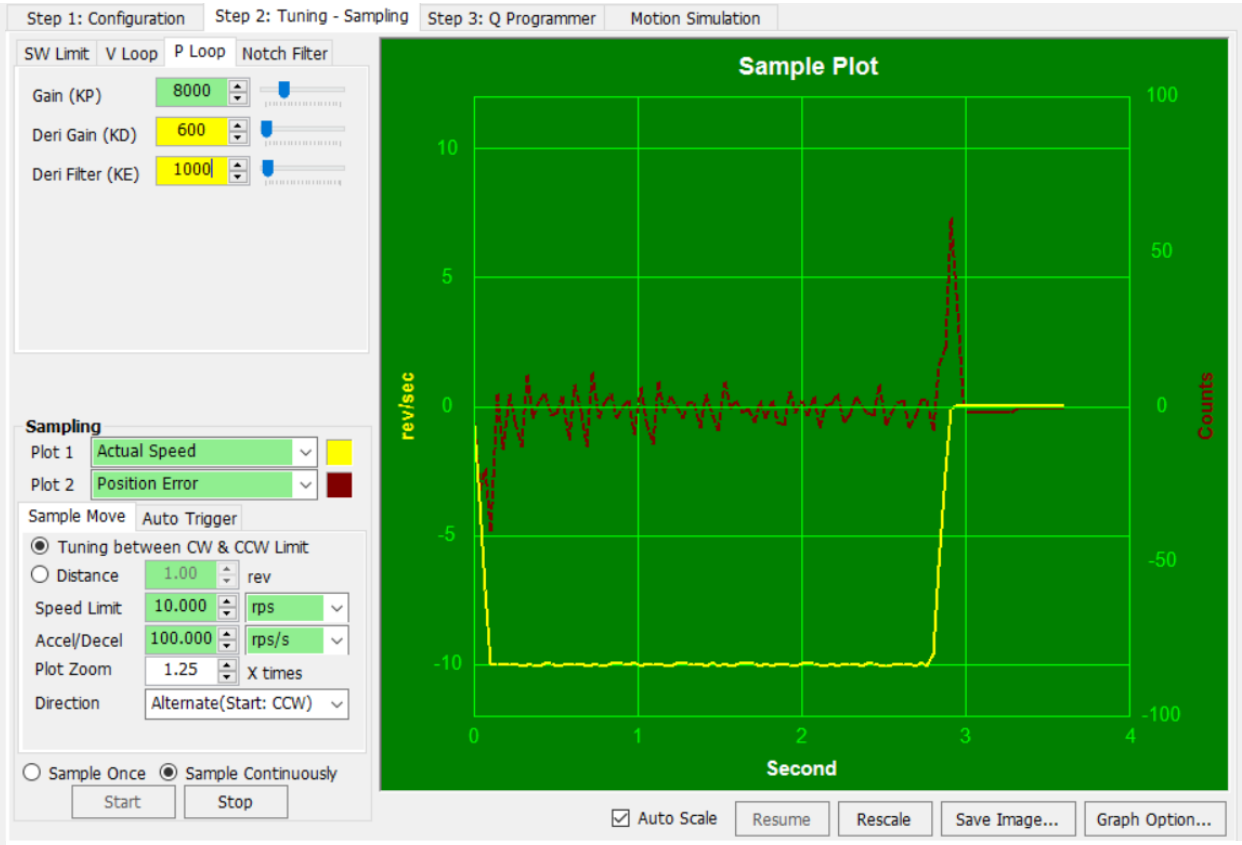


圖(5a) 調整P Loop(位置環)後，位置誤差被最小化



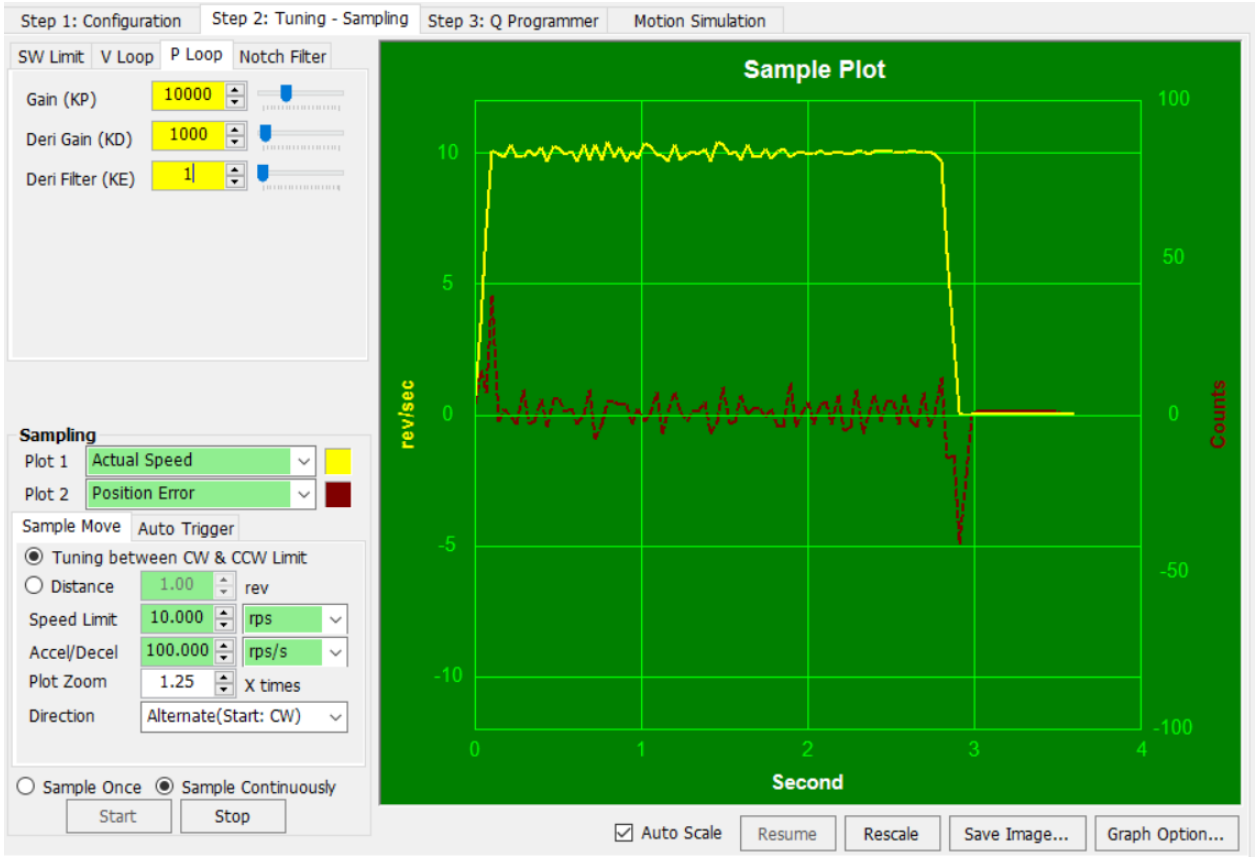
圖(5b) 放大檢視位置誤差曲線，顯示其範圍落在+/-10編碼器計數內

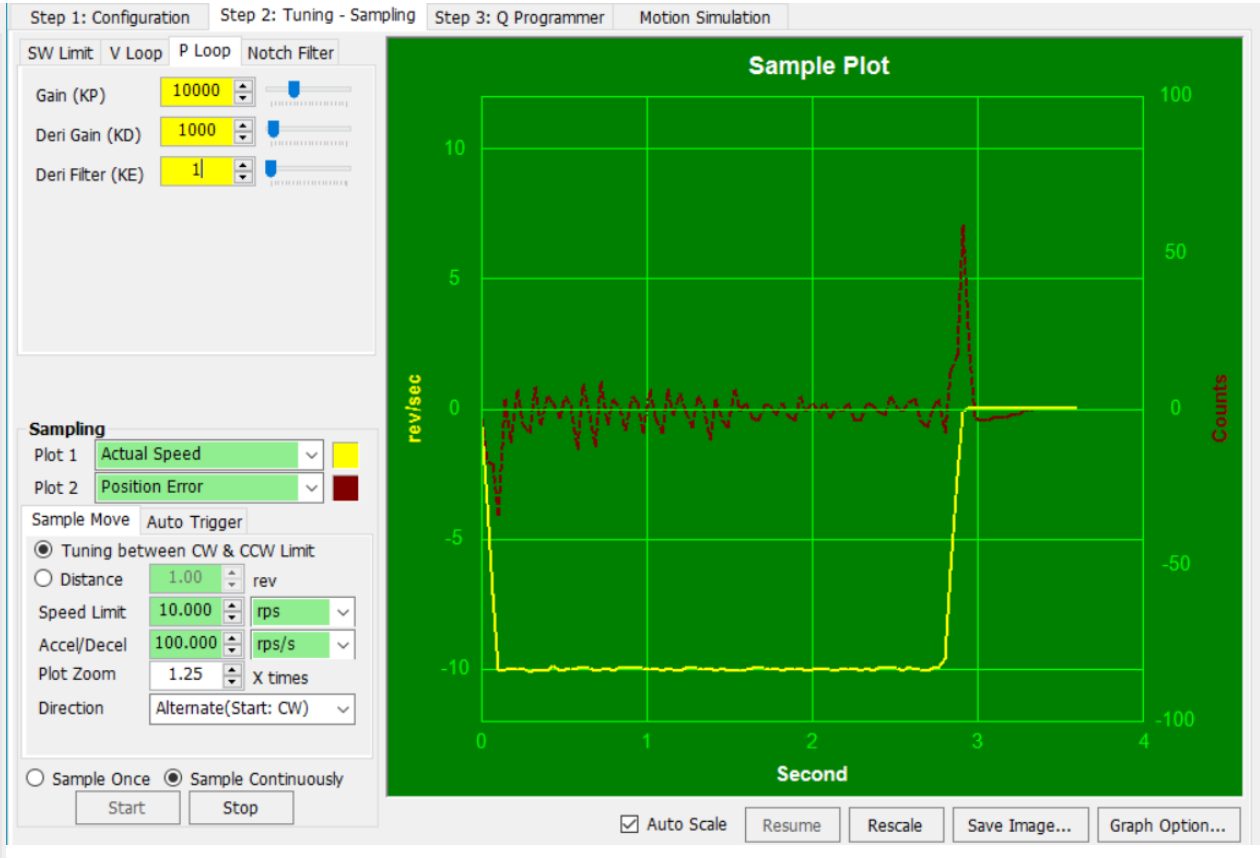
24VDC



KP8000 / KD600 / KE1000

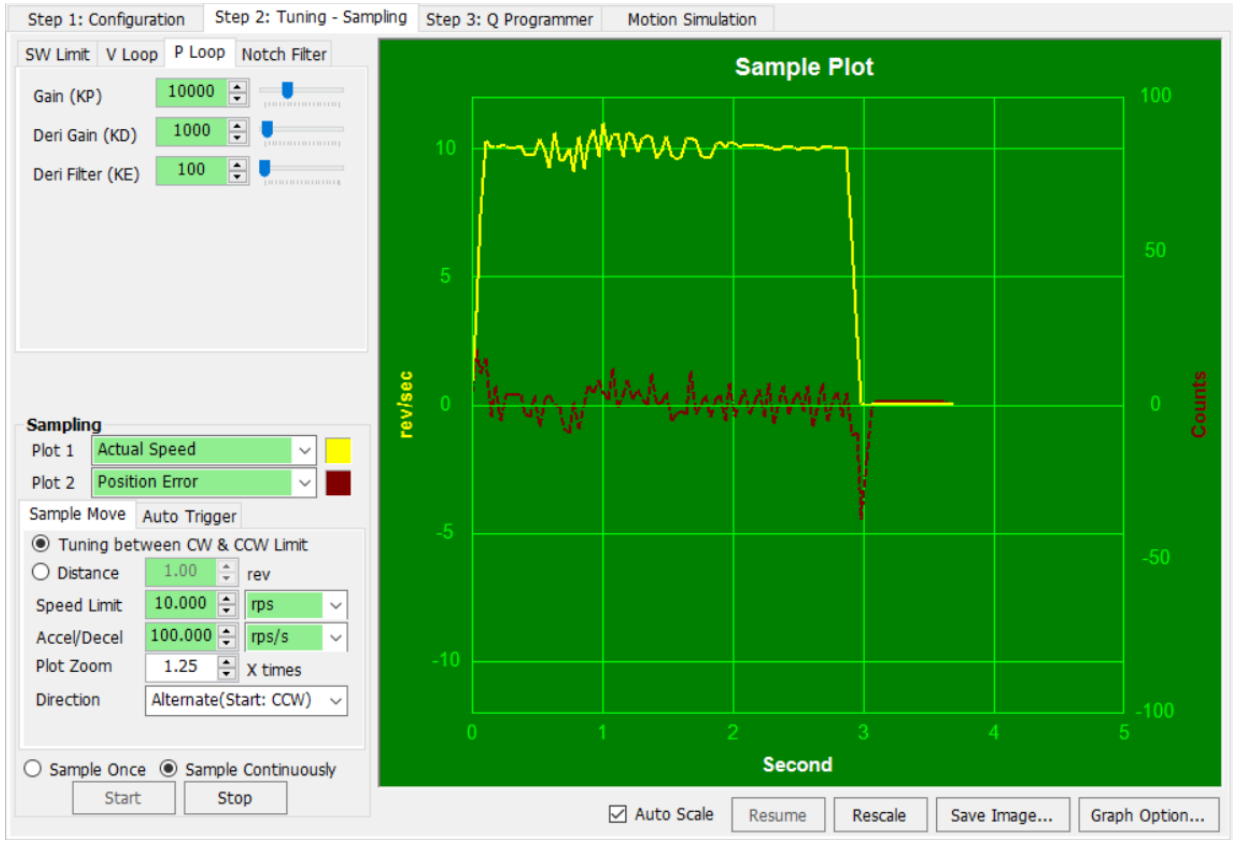
24VDC

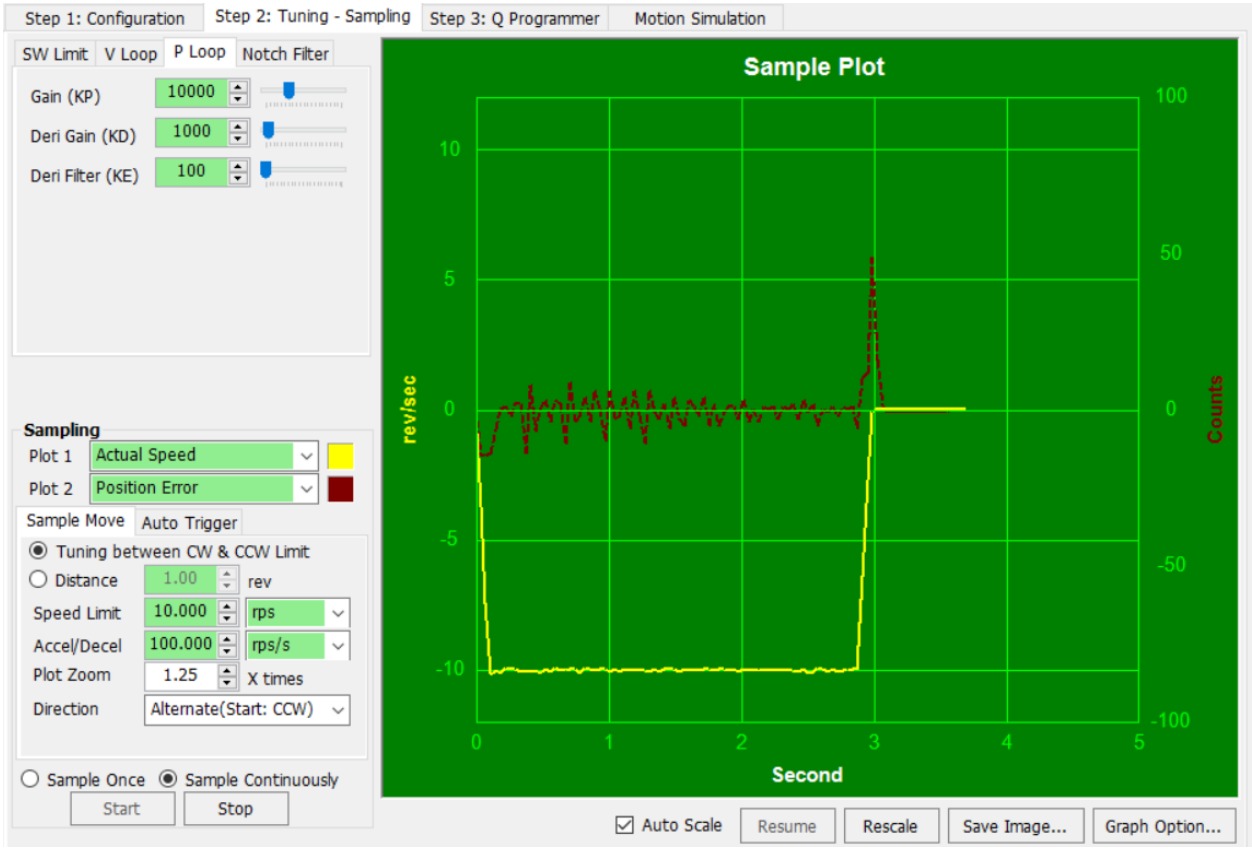




KP10000 / KD1000 / KE1

48VDC





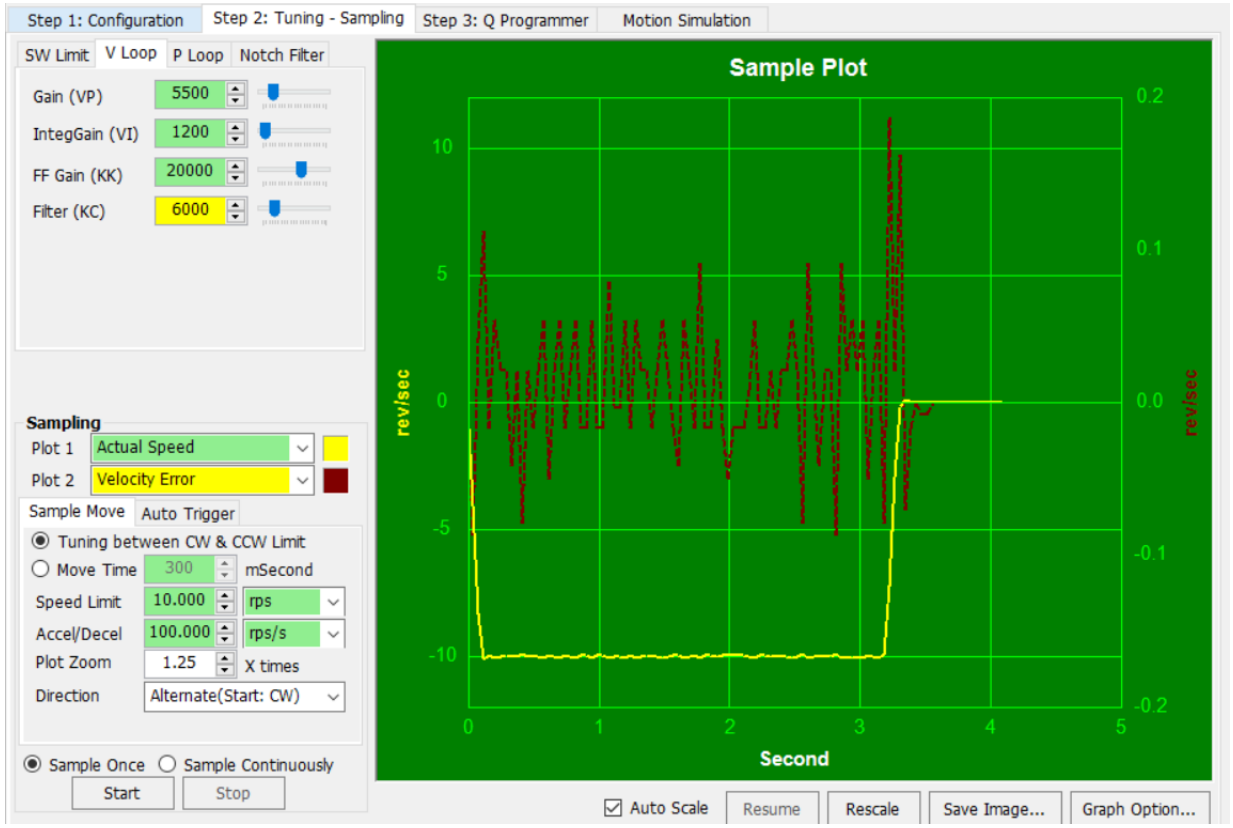
KP10000 / KD1000 / KE100

調整後影片 A

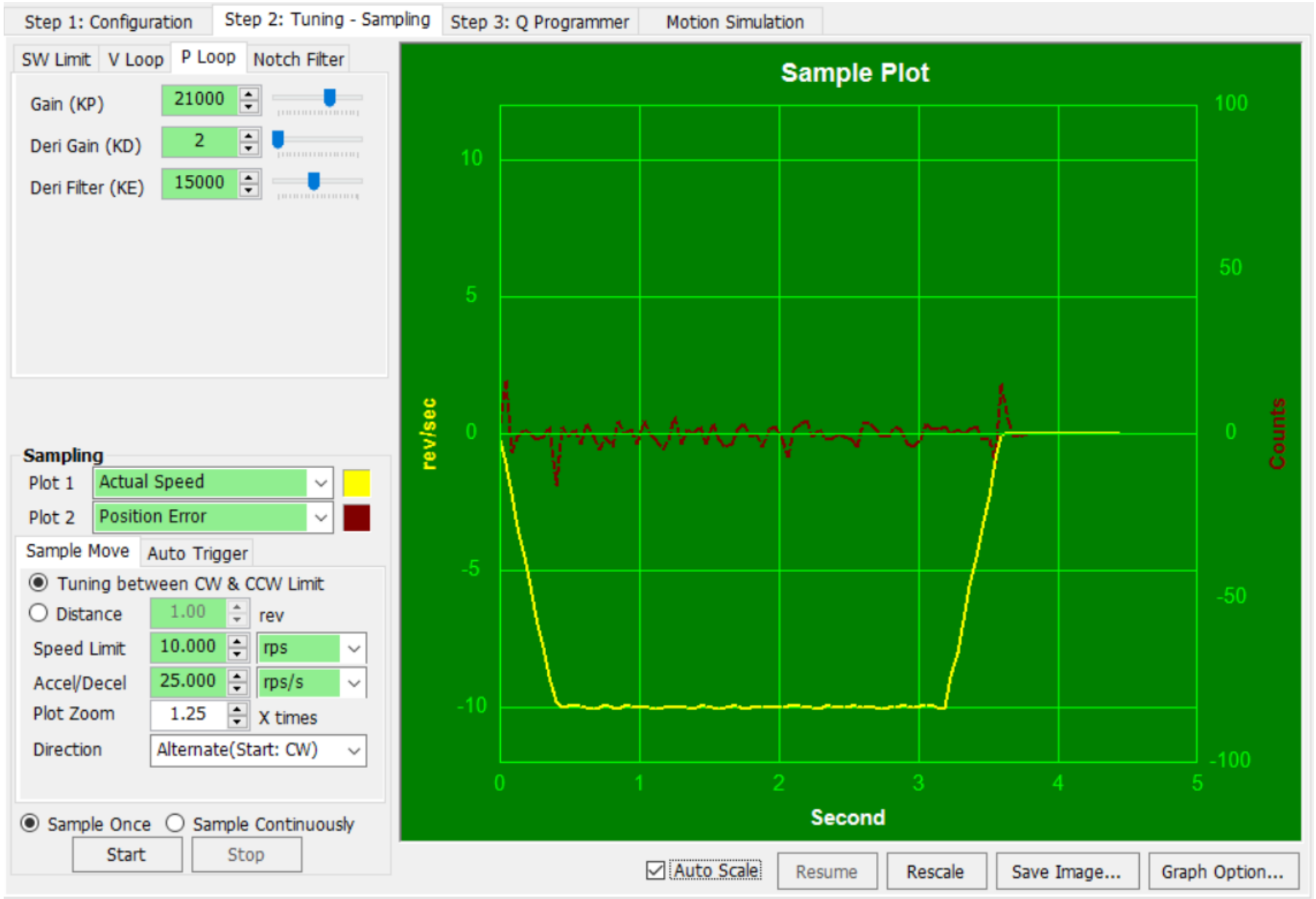
https://youtu.be/Hpc_a_cZUQU?si=czTWQuQLwcSHm_9X

其他PID調整結果-加速度不同

48VDC
V Loop



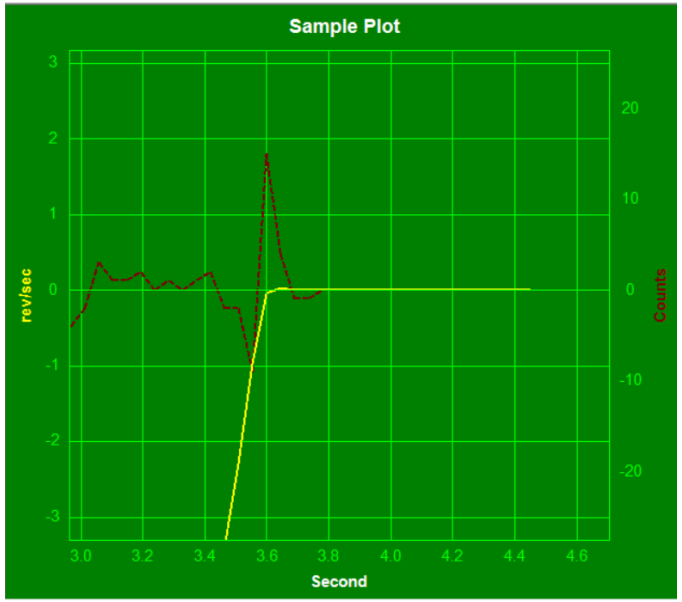
VP5500 / VI1200 / KK20000 / KC6000



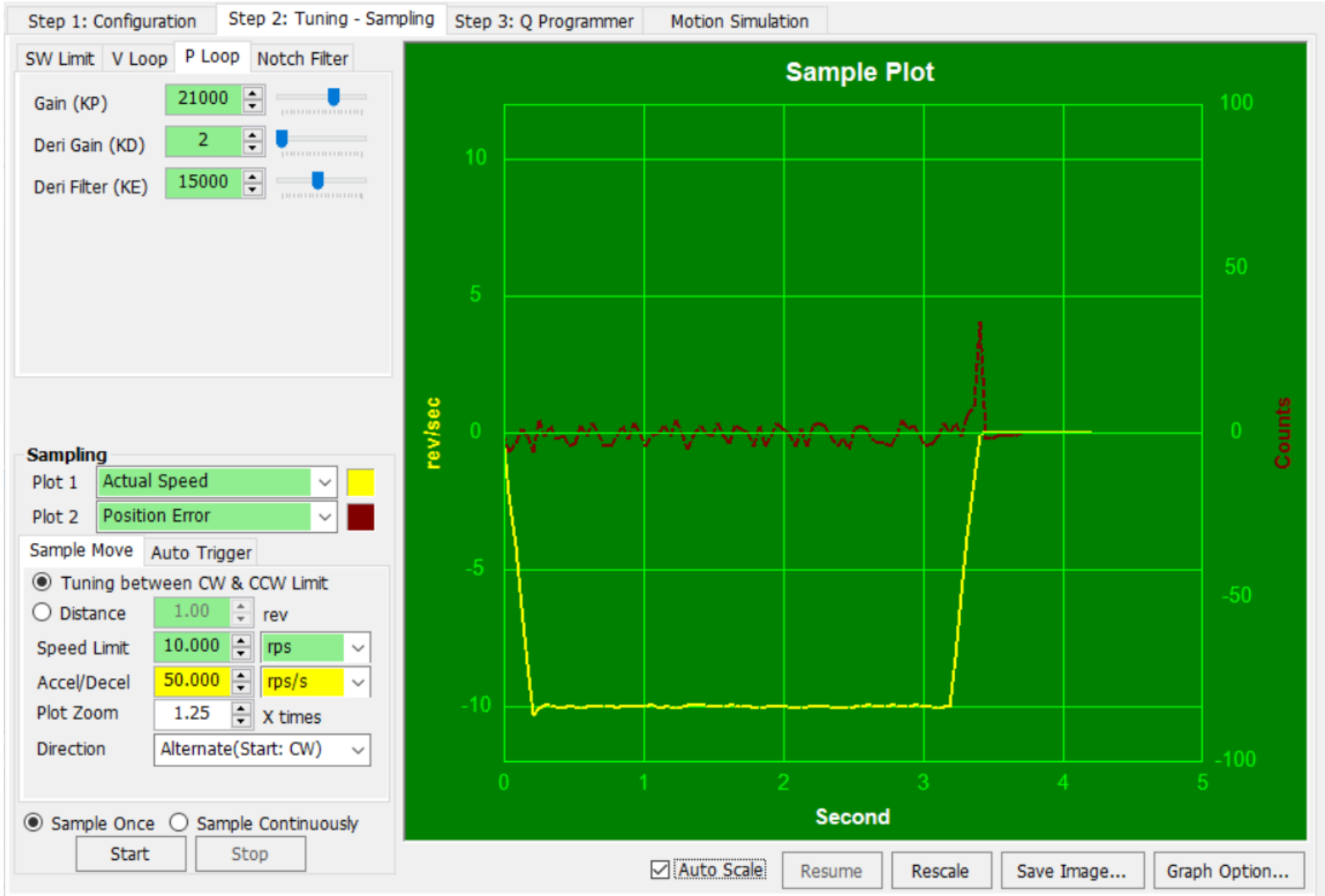
48VDC

P Loop 3

AC/DE=25rps/s



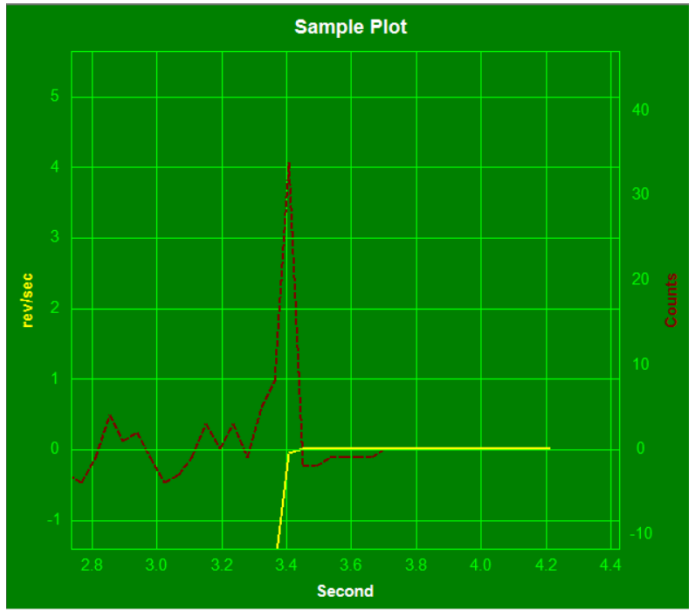
KP21000 / KD2 / KE15000



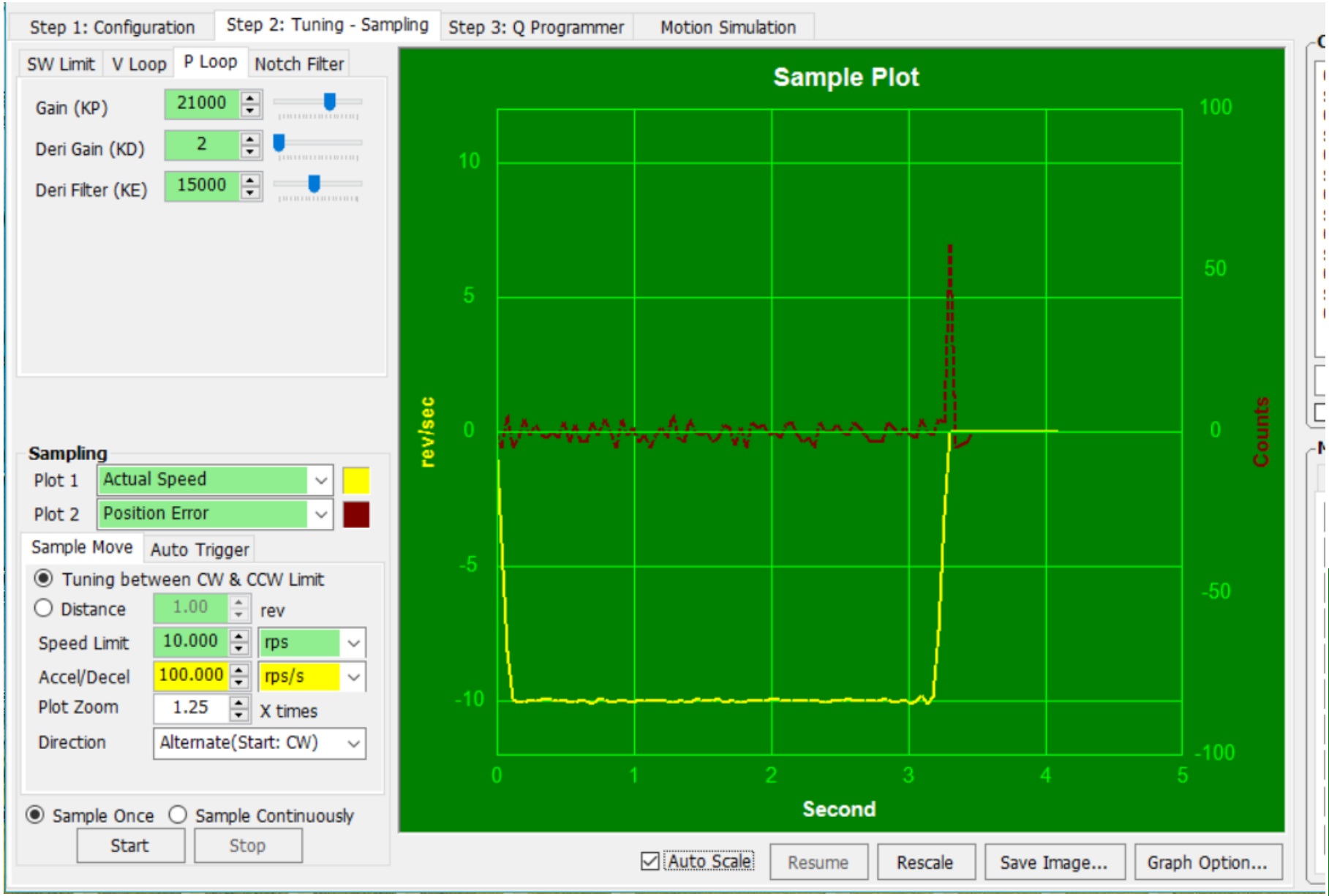
48VDC

P Loop 3

AC/DE=50rps/s



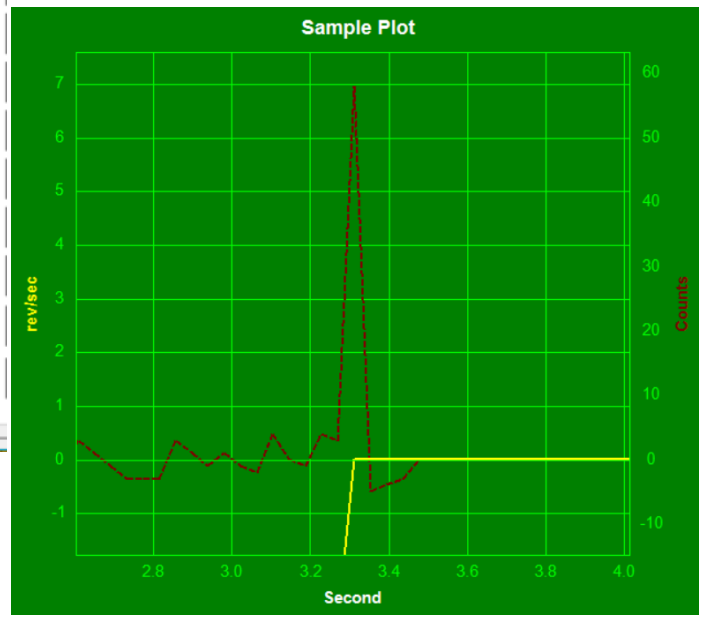
KP21000 / KD2 / KE15000



48VDC

P Loop 3

AC/DE=100rps/s



KP21000 / KD2 / KE15000

調整後影片 B

https://youtu.be/M8uRGMLv9u8?si=EEzc0crOBs8m3lqb