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 **DANAHER**  
MOTION



## Interactive Basic Tuning for the **SERVOSTAR® 600**

Welcome to Danaher Motion's interactive tuning chart. The first three sheets of this document provide a flow chart to describe tuning the servo gains of a **SERVOSTAR 600**. The remaining sheets give more detail.

After you start, click on the following icons:

more...

for extra detail

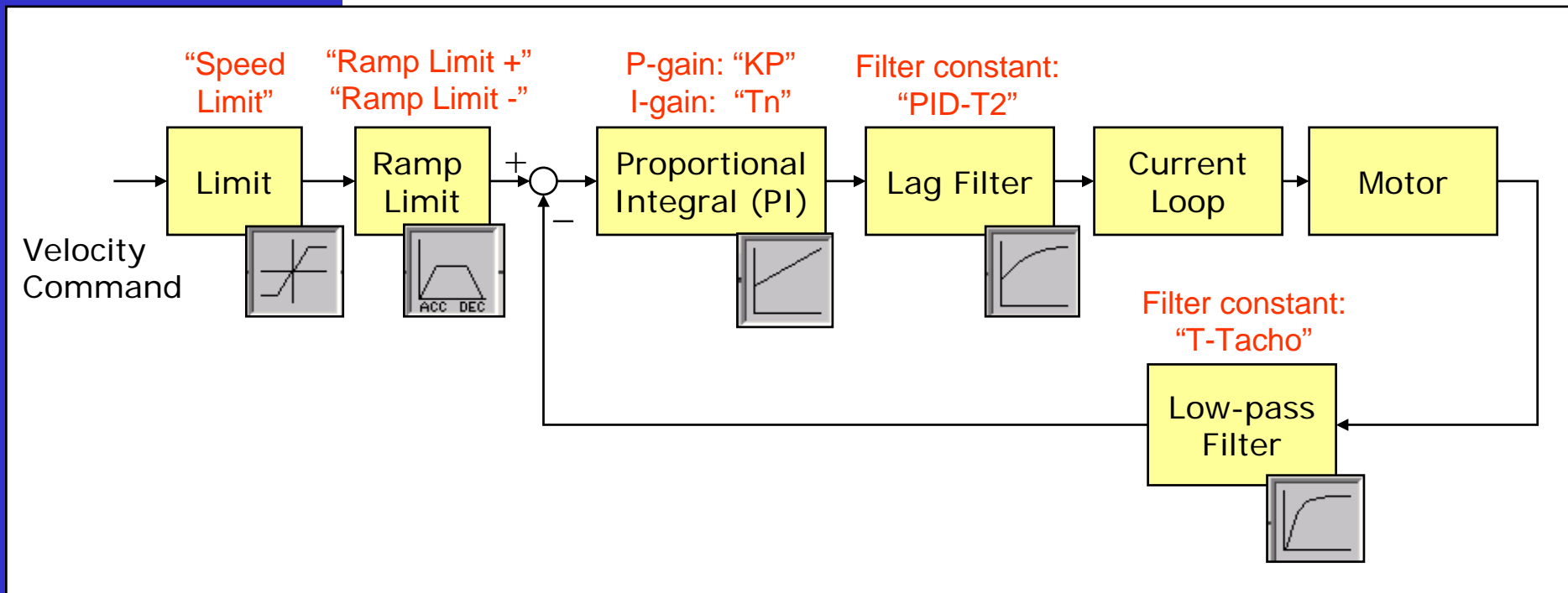
Return...

to return from "more..."

Now, let's get started...click here:

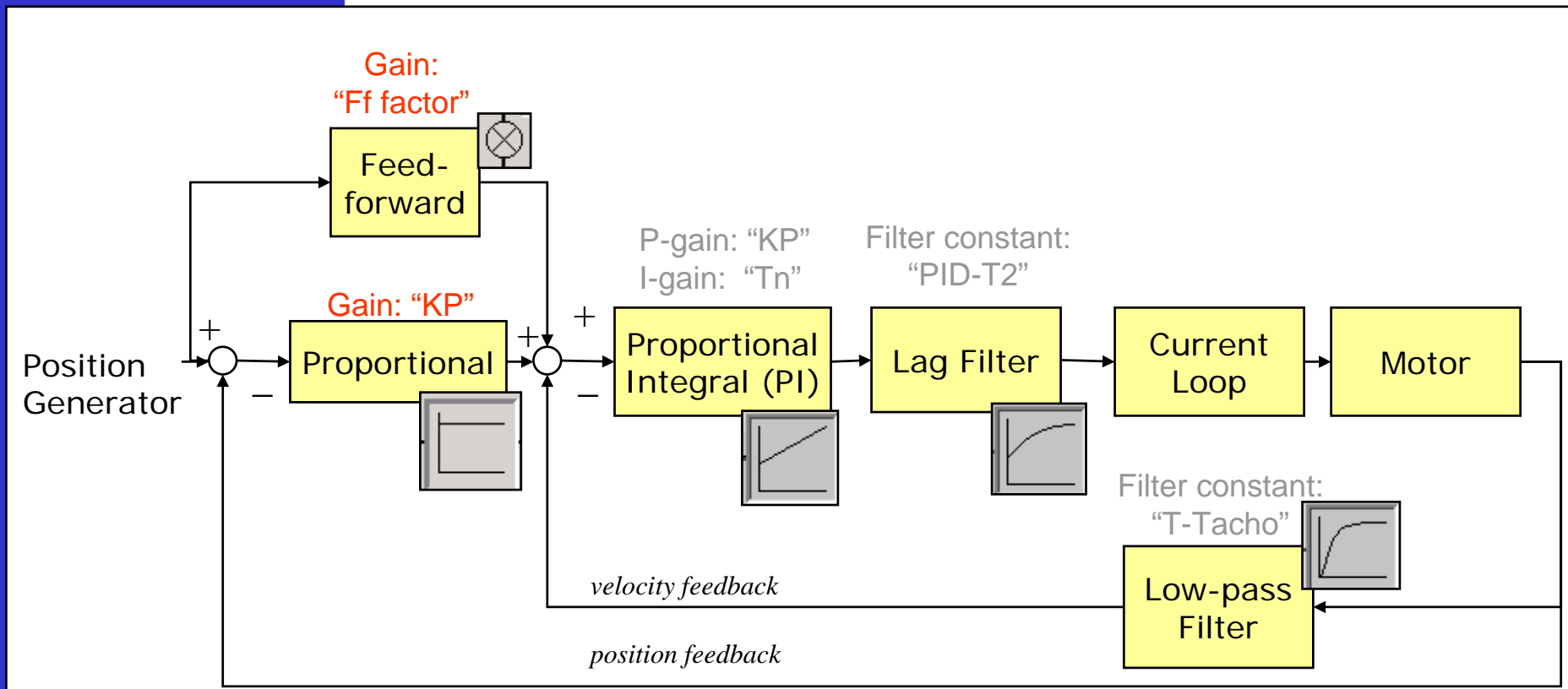
**Next step**

Here is the velocity loop we will tune:



Next step

After we tune the velocity loop, here is the position loop we will tune\*\*:

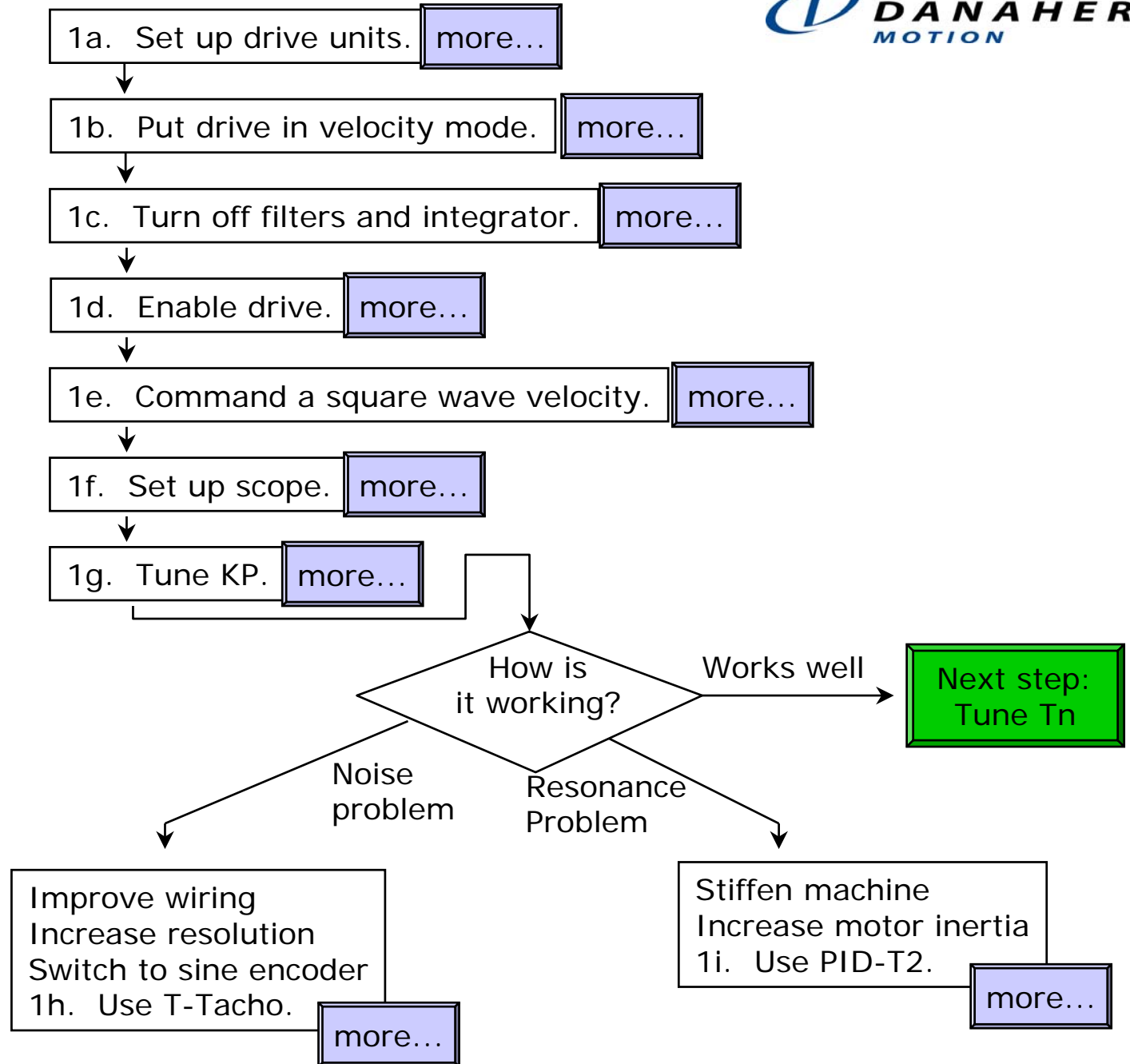


\*\*Those gains shown in red are in the position loop.  
Those gains shown in gray are part of the velocity loop.

Next step

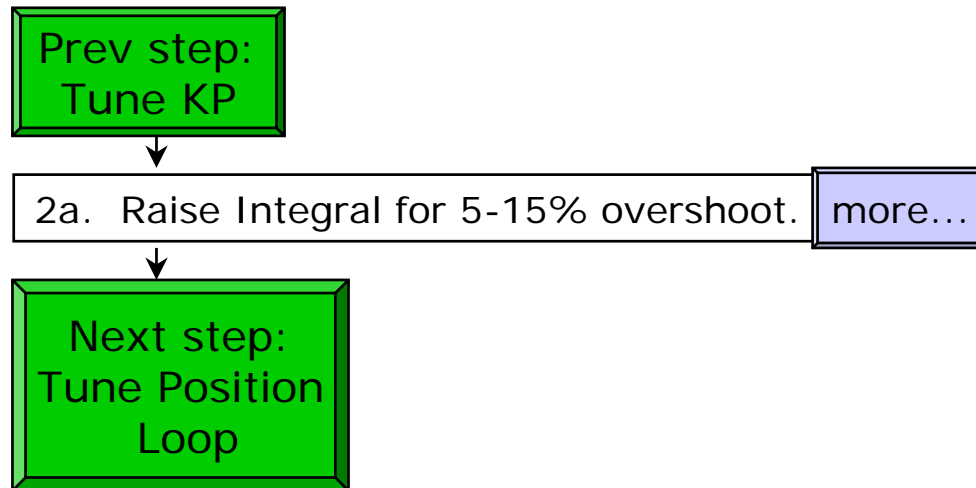
# SERVOSTAR 600 Tuning

## STEP 1: Tune Proportional Gain



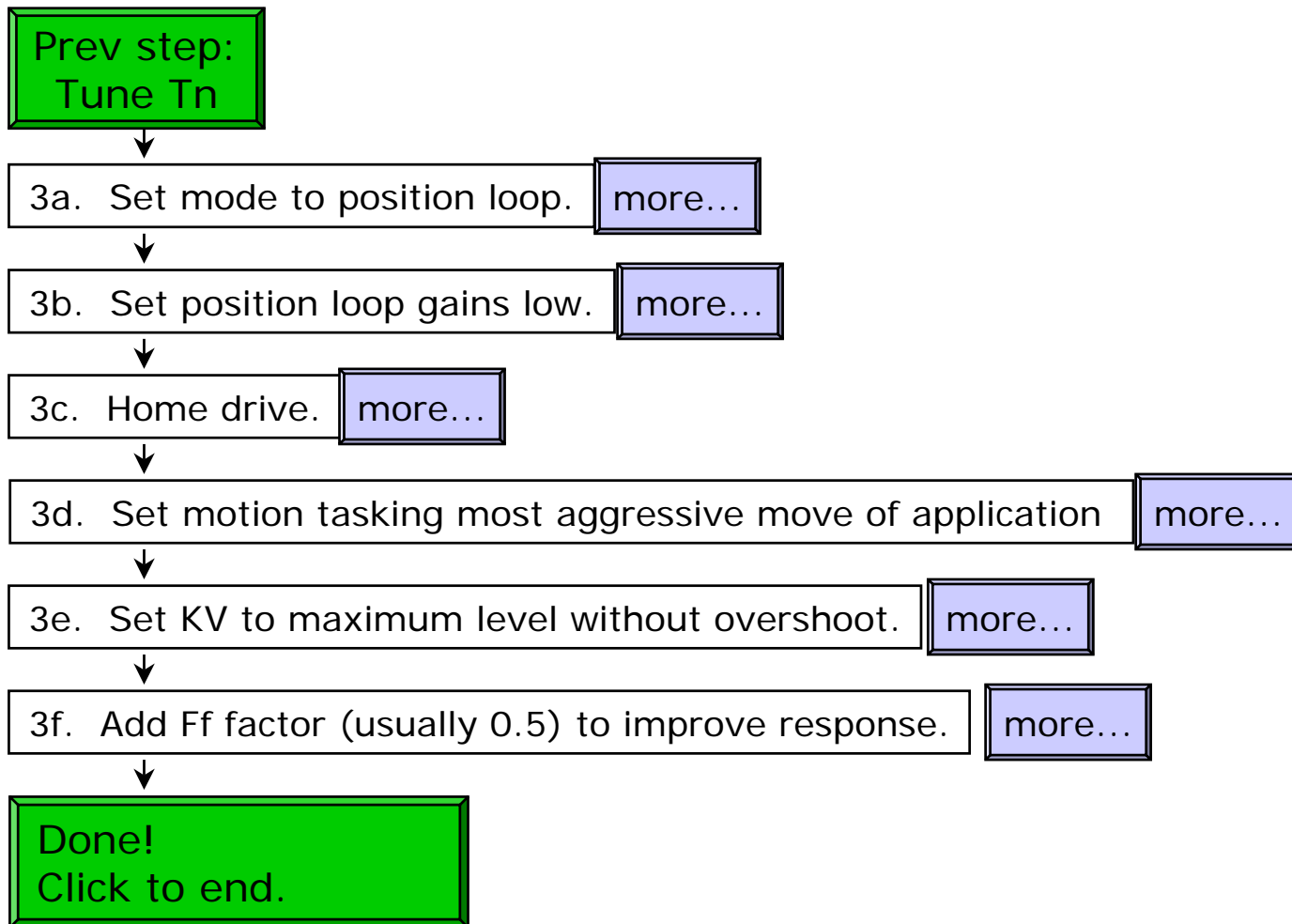
# SERVOSTAR 600 Tuning

STEP 2:  
Tune  
Integral  
Gain



# SERVOSTAR 600 Tuning

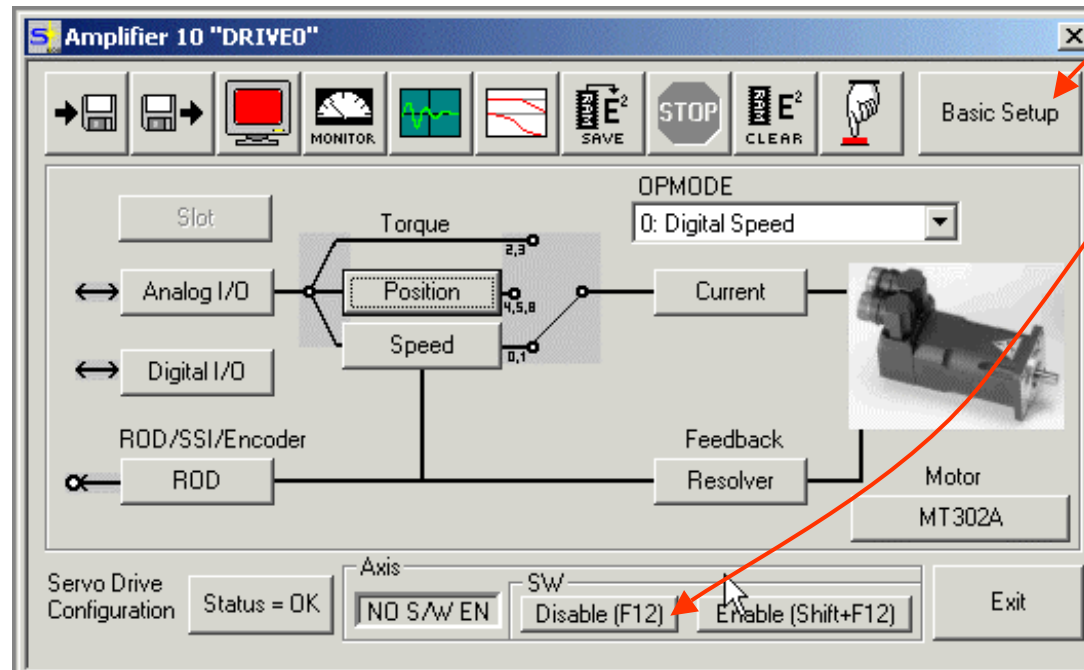
## STEP 3: Tune Position Loop



## Step 1a

This section will give a simplified approach to setting user units. The SERVOSTAR 600 has many variations of units; only a few will be discussed here.

- Disable drive
- Click on Basic Setup



More...

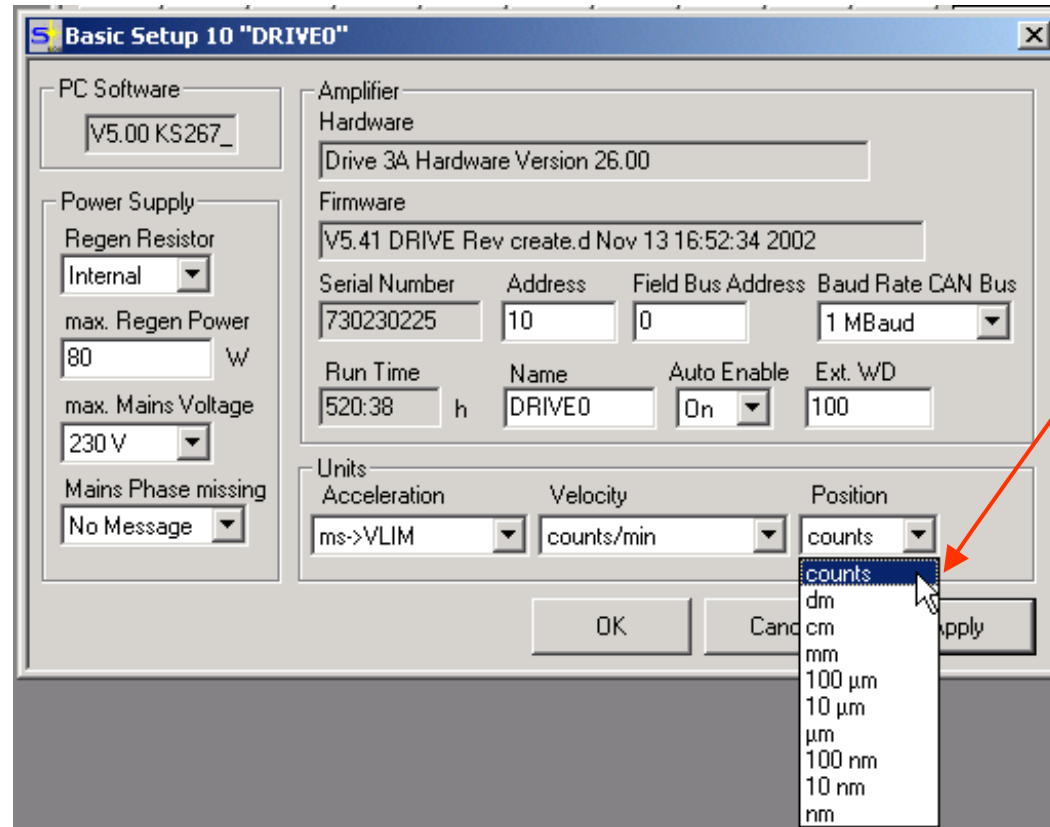
## Step 1a (cont.)

- Select position units, normally mm or “counts”

*Tip: This selection only affects the display of parameters on screen. It has no effect on the operation of the drive.*

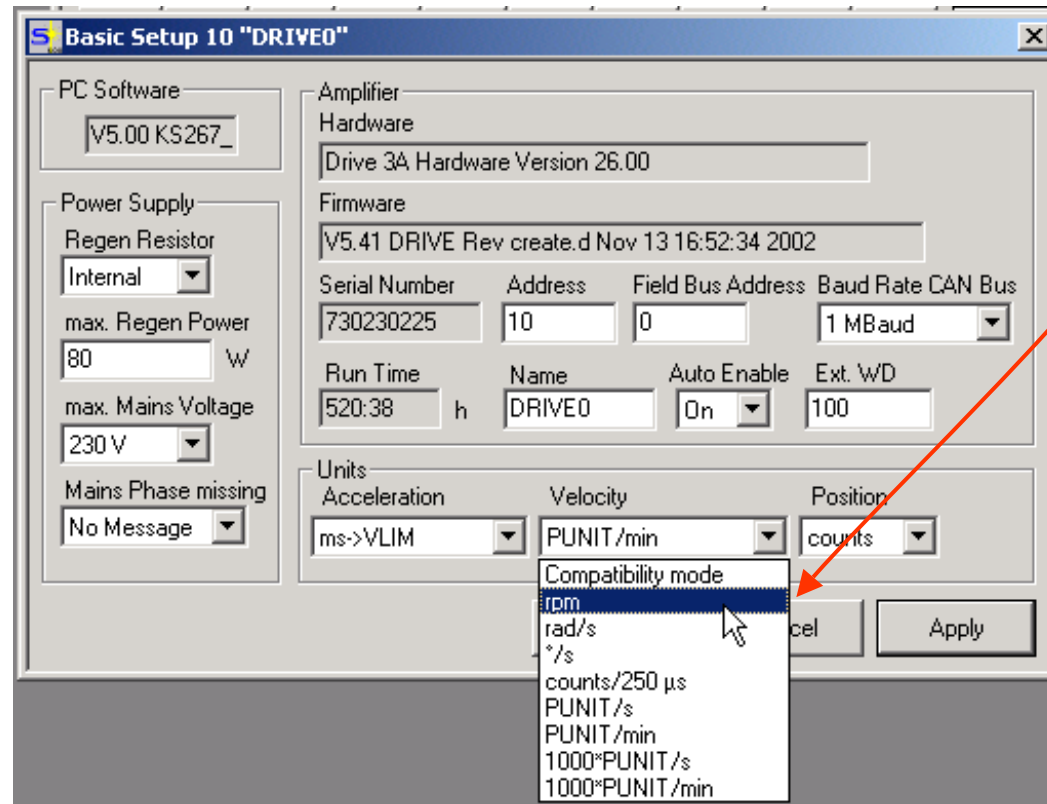
*Tip: If you are using English or rotary units, select counts. Here a “count” will be one user position unit (for example, a mil).*

*Tip: Scale units so you will have necessary precision understanding that all position entries will not have a decimal point.*



Step 1a  
(cont.)

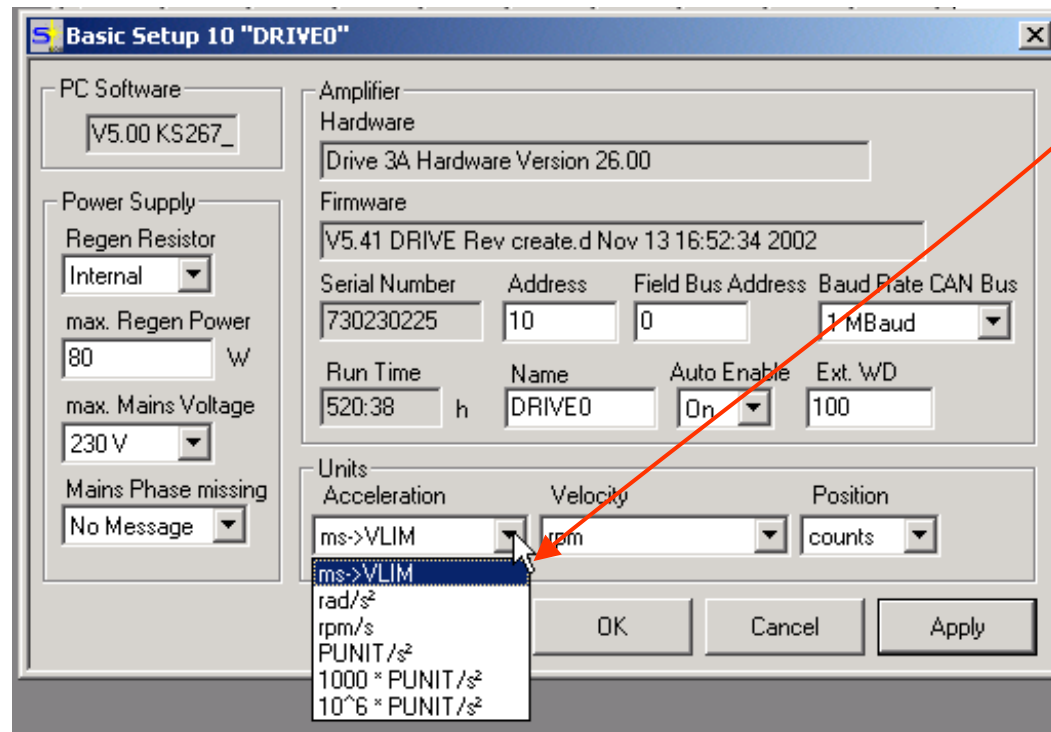
- Select velocity units, normally RPM, PUNITS/min, or PUNITS/s.



More...

Step 1a  
(cont.)

- Select acceleration units, normally ms -> VLIM, which means the time (in msec) from 0 to VLIM, or PUNIT/s<sup>2</sup>.
- Click OK



More...

Step 1a  
(cont.)

- Click "Position"; then "Position Data"
- Enter the number of position units per rev
  - Example: for degrees, enter 360.
- Set system limits on acceleration and velocity

The screenshot shows the 'Amplifier 10 "DRIVE0"' software interface. The 'Position Data 10 "DRIVE0"' window is open, displaying configuration options for Motion Task 1. The 'Resolution' is set to 360 counts, and the maximum velocity ('v max') is set to 3000 rpm. The 'Axis Type' is set to Rotary. The 'Limit Switch / Position Threshold' table shows all four registers are inactive. The 'Status = OK' and 'Axis = ENABLED' indicators are visible in the bottom left. A 'Return...' button is located in the bottom right corner.

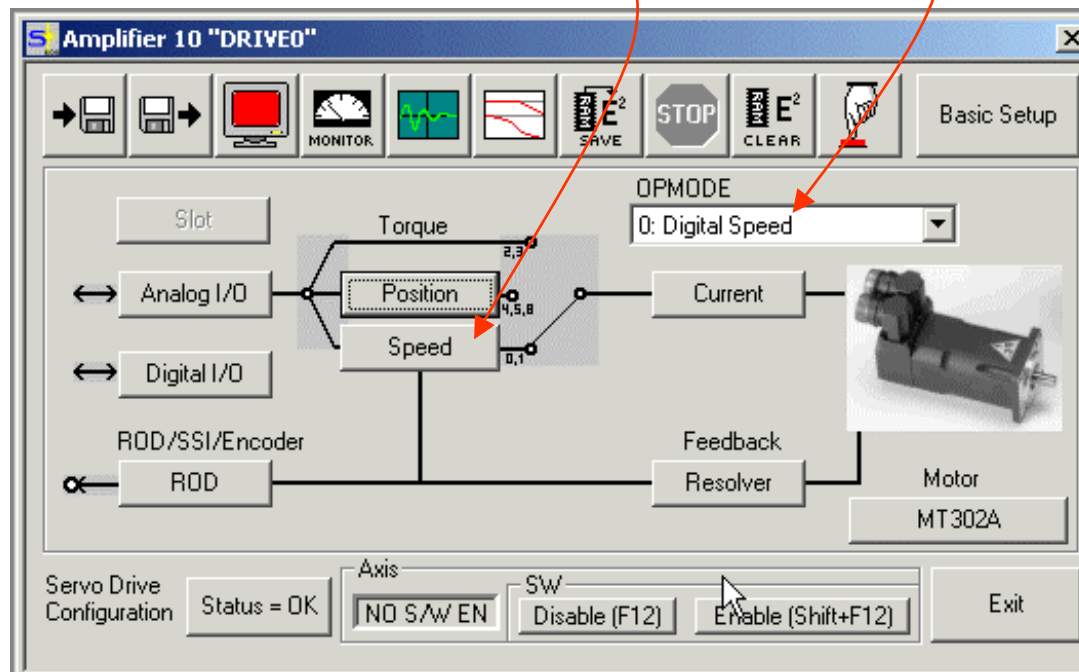
Position Register	Position
1: Inactive	0
2: Inactive	0
3: Inactive	0
4: Inactive	0

Parameter	Value	Units
Axis Type	Rotary	
t acc/dec min	1	ms->v_max
InPosition	4000	counts
v max	3000	rpm
modulo start pos.	-2147483648	counts
modulo end pos.	2147483647	counts
Resolution	360	counts
Resolution	1	Revolution(s)

GMT

## Step 1b

- Set OPMODE = "0: Digital Speed"
- Click Speed button.



*Tip: Start by tuning the velocity loop.*

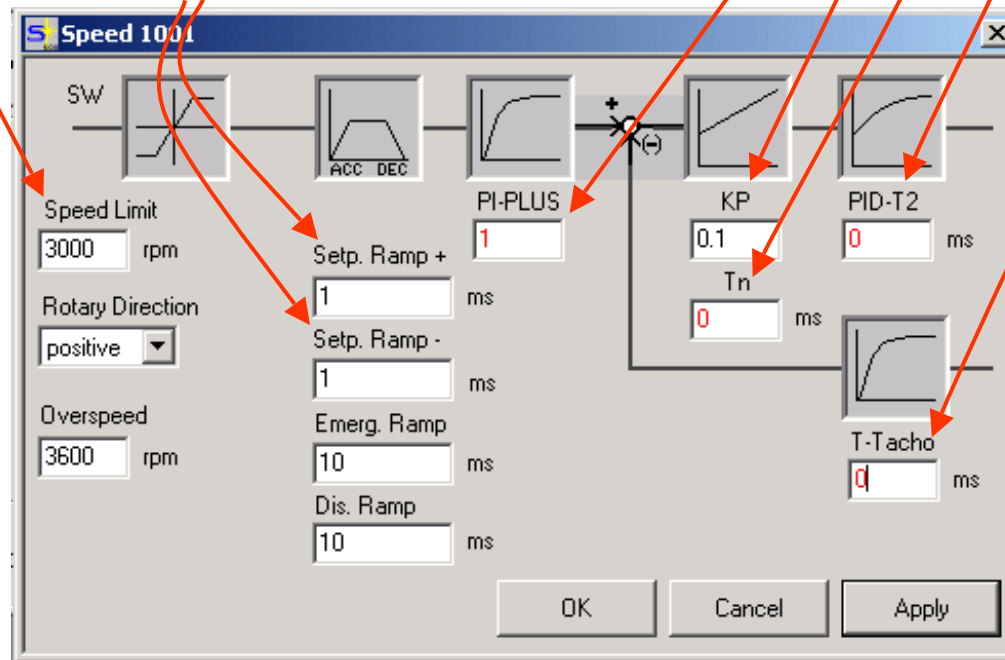
Return...

## Step 1c

- Minimize filters: PID-T2=0, T-Tacho=0 (if T-Tacho is gray, skip setting T-Tacho to 0).
- Zero integral (Tn = 0)
- Set KP very low (KP  $\square$  0.1)
- Enable PI: Set PI-PLUS = 1
- Check top speed.
- Set accel times to 1ms

*Tip: Turn off the filters for now...they will be used later if necessary.*

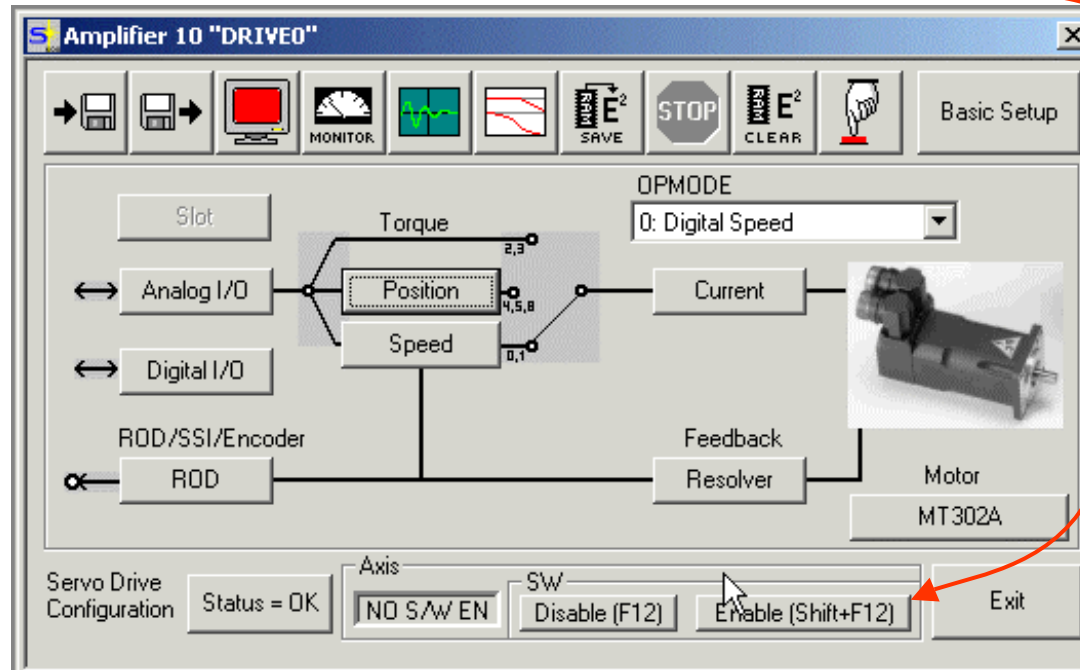
*Tip: Setting Tn=0 makes the system proportional control to simplify tuning. Vertical axes may drift if you zero the integral. If your load will fall when the integral is zeroed, do not zero Tn.*



Return...

# Step 1d

- Enable drive



*Tip: The system has very low gain. Expect it to be soft. If the system oscillates or produces any unexpected movement, remove power.*

Return...

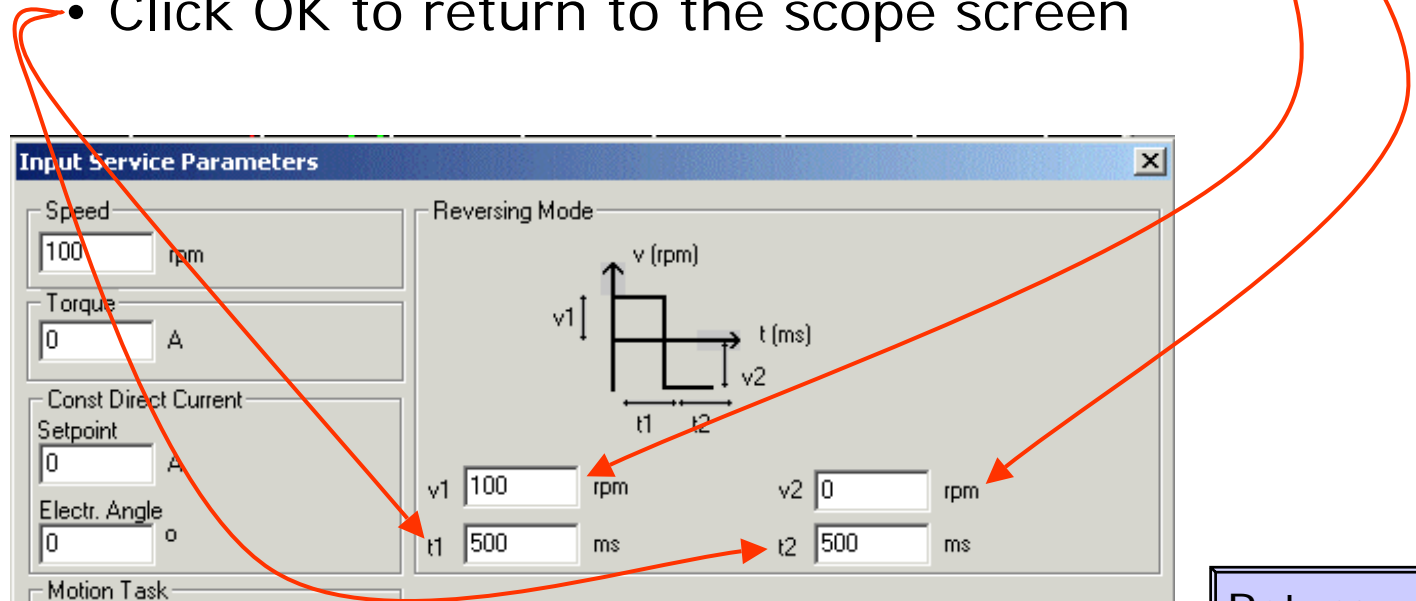
## Step 1e

### Set up reversal speed

- Click on the Scope button (from main screen)
- Click on the Parameters button (scope screen)
- Set reversing mode from 100 to 0 RPM
  - Range is usually  $< 10$  RPM for DDR.
  - For linear motion, set  $v1 = -v2$  to limit motion
- Set time for 500 msec at both speeds
- Click OK to return to the scope screen



Parameters



Return...

*Tip: You must avoid saturating the current controller when tuning. This is why high inertia systems often should be given just 5 or 10 RPM step commands. If you aren't sure, just proceed and this will be corrected later in the procedure.*

## Step 1f

### Set up scope

- Set Time/Division to 10ms
- Trigger Level 1, Trigger Position 25%
- Select Reversing, and then Start.



Return...

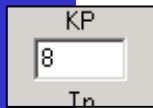
*Tip: In high friction systems, the system may not move at all because of the low gain. If that's the case, raise gain in increments of 50% until you see movement.*

*Tip: When the integral is turned off, the speed will often not reach top speed because of friction. In the scope shot at right, this can be seen where velocity (green) does not reach command (red).*

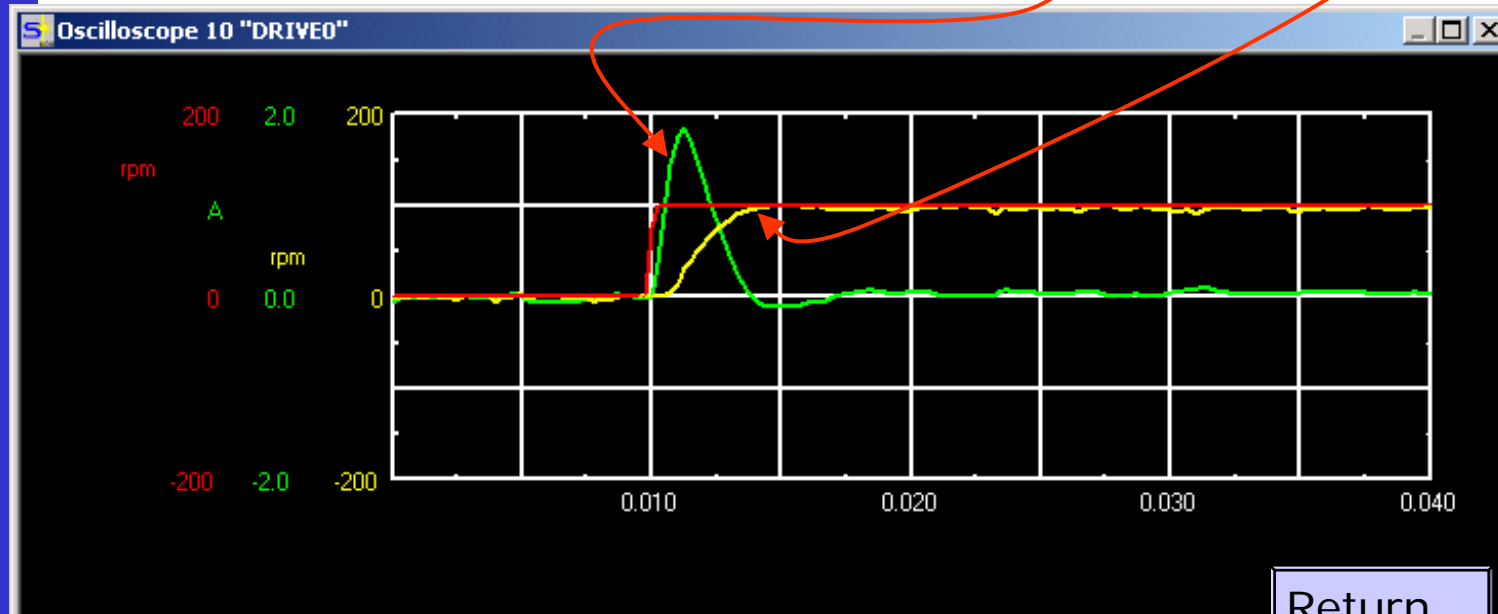
# Step 1g

## Tune KP

- Start record with Start Record on scope window
- Raise KP to maximum value without overshoot
  - Set KP from “Speed” screen.
- Ensure that the current does not saturate



more...



Return...

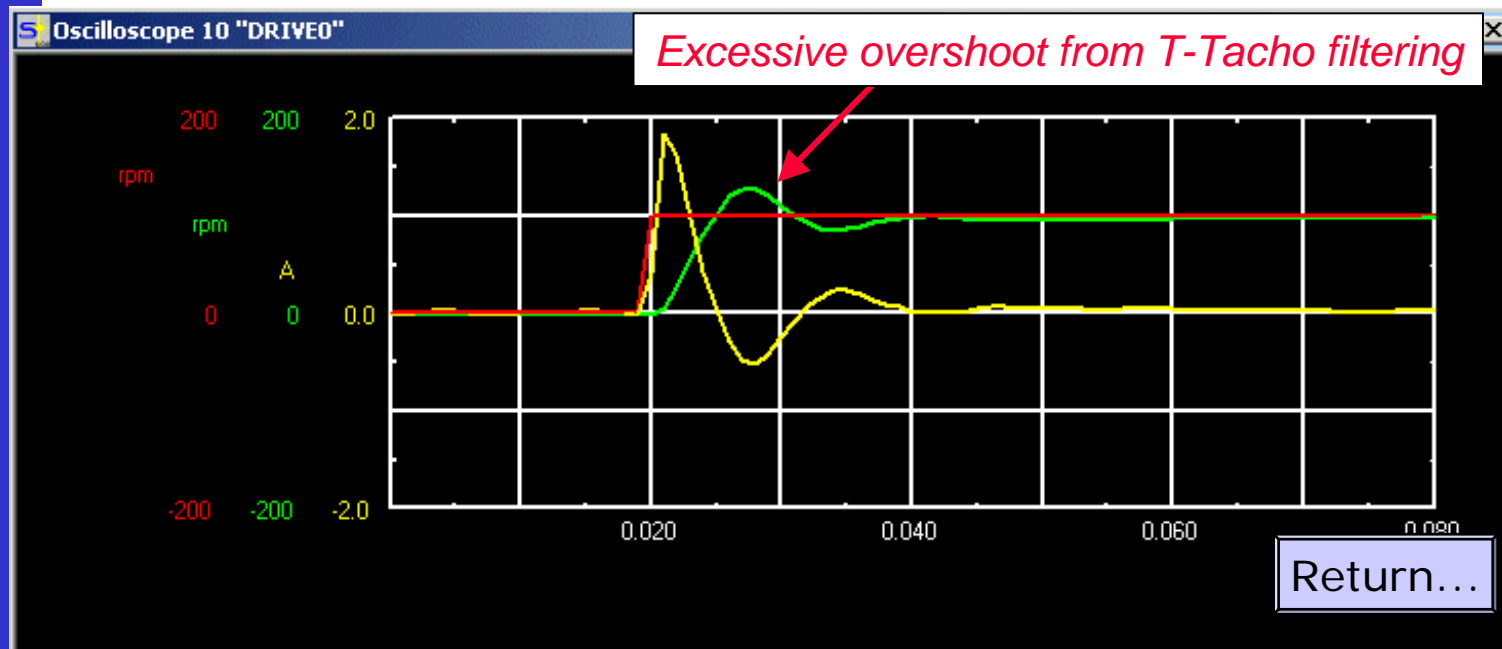
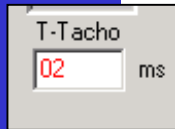
*Tips: A well tuned SERVOSTAR 600 driving a motor with a rigid load can respond to speed changes as fast as 5 ms without overshoot!*

*There are two start buttons on the Scope screen. One for motion and one for recording.*

## Step 1h

### Resolution noise

- Start with KP only; ensure  $T_n = 0$ .
- If there is too much resolution noise, increase T-Tacho to reduce noise (from "Speed" screen)
- Adjust T-Tacho and KP together. Maximize KP and minimize T-Tacho; avoid 10+% overshoot.
  - Start with T-Tacho 0.1; keep it as low as possible.



*Tip: Resolution noise is best solved by getting a more highly resolved feedback sensor. Consider switching to a sine encoder for the best resolution available!*

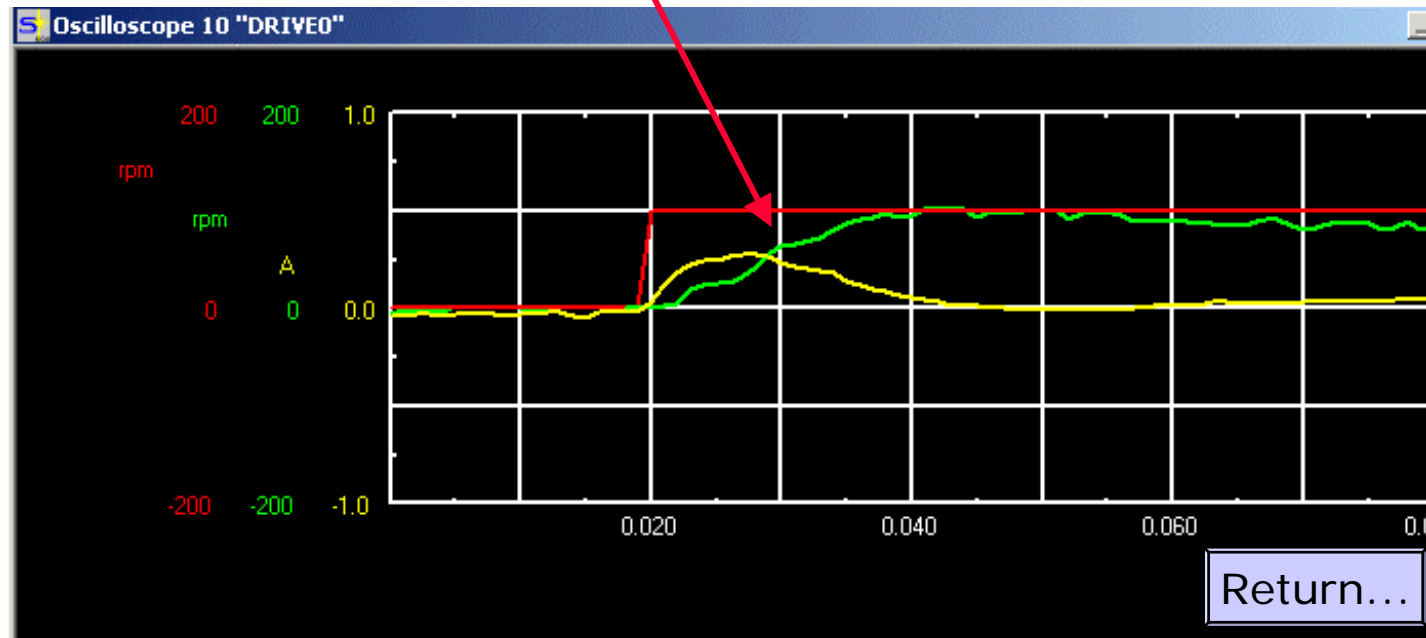
## Step 1i

### Resonance: Using PID-T2

- Use PID-T2 to allow higher KP
- Adjust both gains simultaneously to maximize KP
- Allow little ringing

KP	PID-T2	
2.5	6	ms
Tn		

*Small amount of ringing is okay*



*Tip: Resonance is a problem best solved mechanically by stiffening the load, increasing the motor inertia, or reducing load inertia. Filtering techniques work, but they make it harder to get a responsive system.*

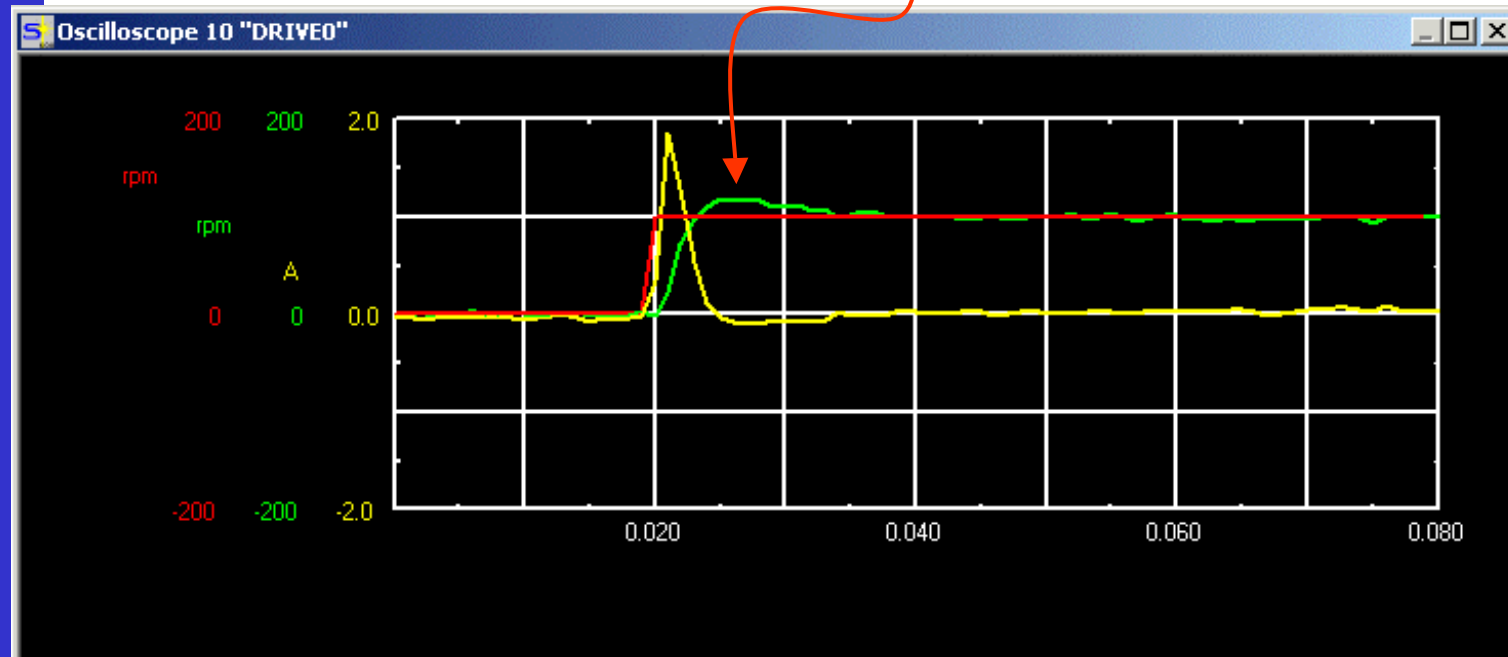
## Step 2a

### Tune Tn

- Start with  $T_n \sim 3$  times the settling time of Step 1
  - Set  $T_n$  in “Speed” screen. Example, if settling time from Step one is 10 ms, start with  $T_n=30$ .
- Lower  $T_n$  for 10-20% overshoot

Tn

8

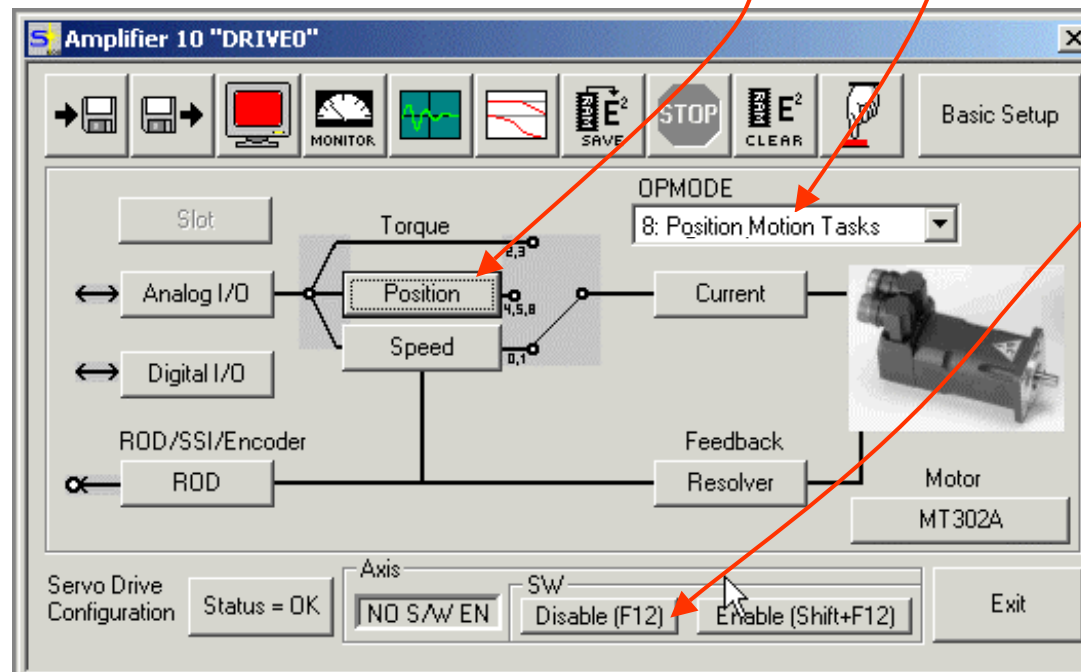


*Tip: Some systems don't need any integral gain. Integral gain provides total elimination of error at when the system comes to rest. If you don't need this, you may want to set  $T_n = 0$  to simplify tuning.*

Return...

## Step 3a

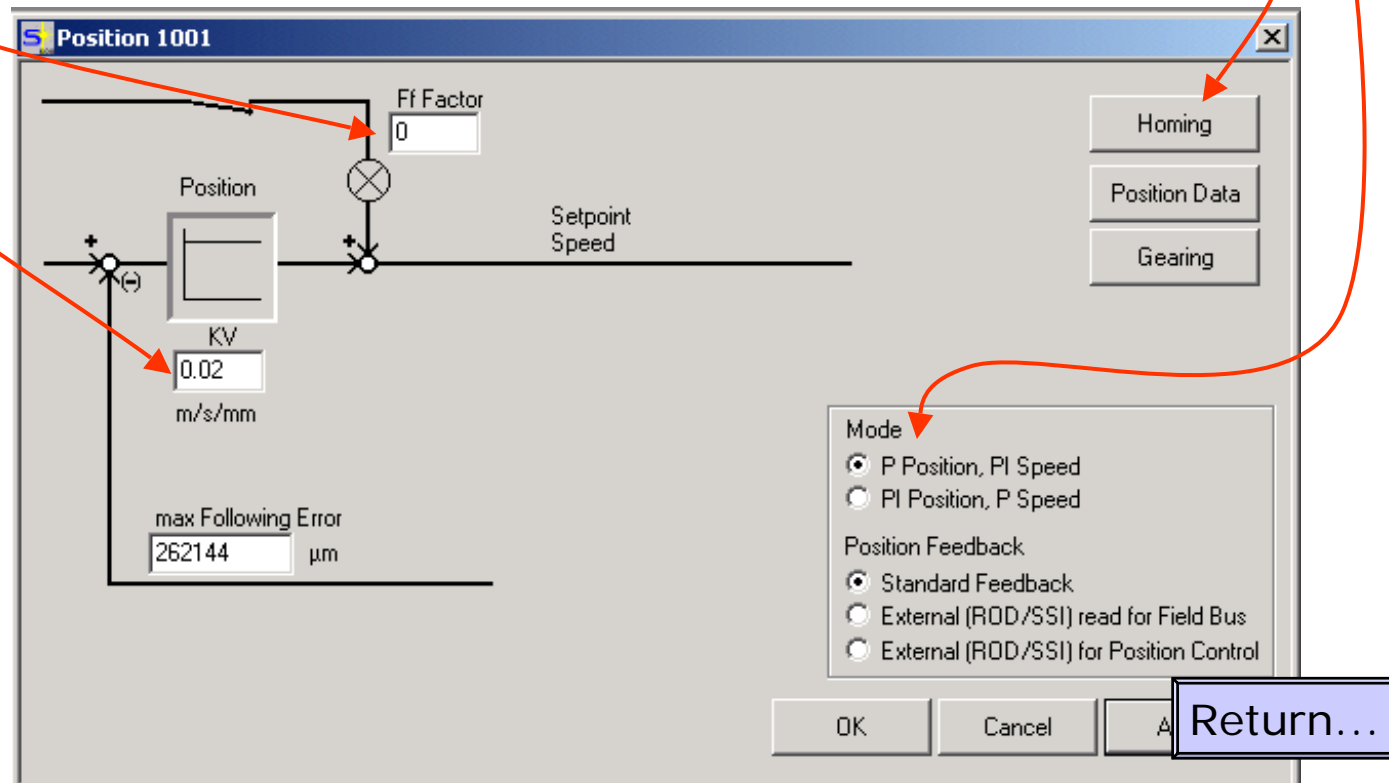
- Disable drive
- Set OPMODE = "8: Position Motion Tasks"
- Click Position button.



Return...

## Step 3b

- Set Mode to P Position, PI Speed.
  - Save and Coldstart if necessary.
- Set KV = 0.02 (low gain, to avoid instability).
- Set Ff Factor = 0.
- Click Homing button (used in the next step).

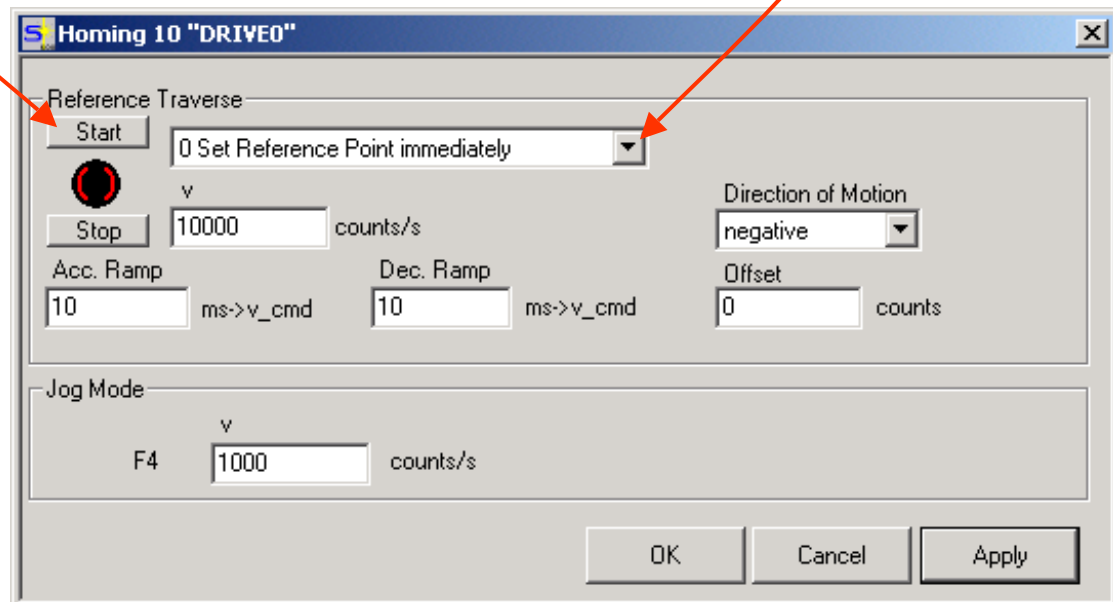


The screenshot shows the 'Position 1001' control interface. The 'Mode' section has radio buttons for 'P Position, PI Speed' (selected), 'PI Position, P Speed', and 'Standard Feedback'. The 'Position Feedback' section has radio buttons for 'Standard Feedback' (selected), 'External (ROD/SSI) read for Field Bus', and 'External (ROD/SSI) for Position Control'. The 'KV' field is set to 0.02 m/s/mm. The 'Ff Factor' field is set to 0. The 'max Following Error' field is set to 262144 μm. The 'Homing' button is visible on the right side of the interface. A 'Return...' button is highlighted in a blue box at the bottom right.

## Step 3c

### Home system

- Enable drive (from main screen)
- Select 0 "Set Reference Point immediately"
- Click Start and OK.



Return...

## Step 3d

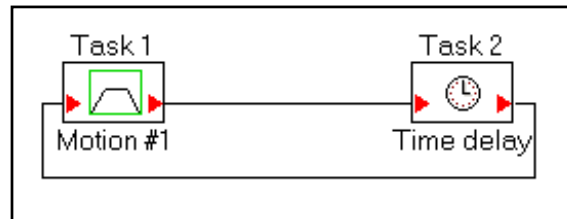
### Set Motion Command

- Using Motion Tasking or Graphical Motion Tasking, create a continuous move (see the interactive Guide “Using GMT” for details).
- Set acceleration and deceleration rates for the most aggressive that will be seen in the application.
- Follow the move with a dwell command of 0.5 seconds.
- Start the task using “Start” (from Position Screen)

*Tip: For linear systems, you should use four tasks:*

- 1) Move forward
- 2) Delay
- 3) Move back
- 4) Delay (back to 1)

*This will prevent the system from moving very far during this process.*



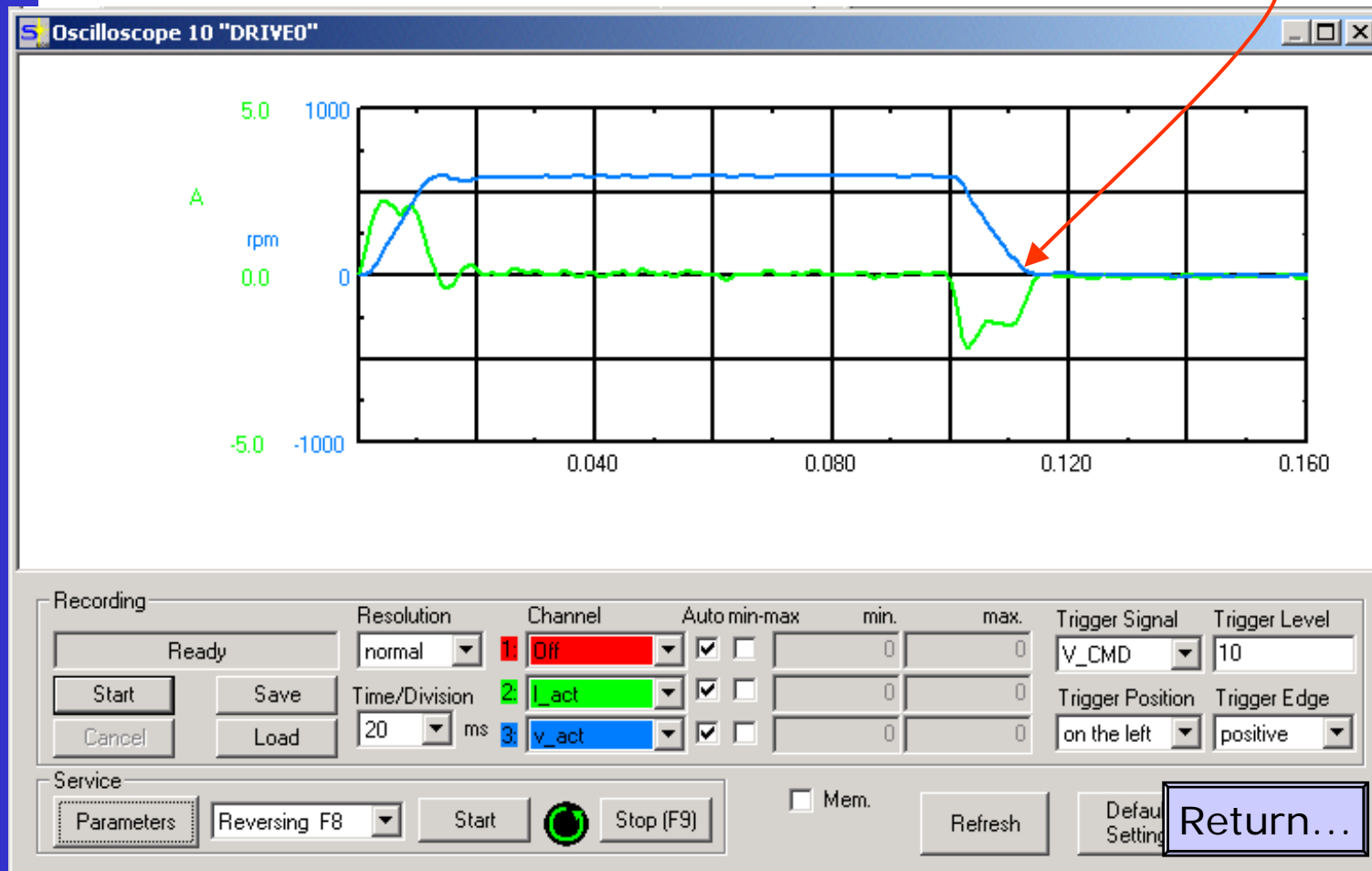
*Graphical Motion Tasking makes a continuous loop easy to program*

Return...

## Step 3e

### Tune Position Loop gain

- Raise KV in steps of 20% to maximum level without overshoot (from Position screen).



*Tips: When in positioning mode, V\_CMD is an internal signal, so it's best to turn it off as shown here.*

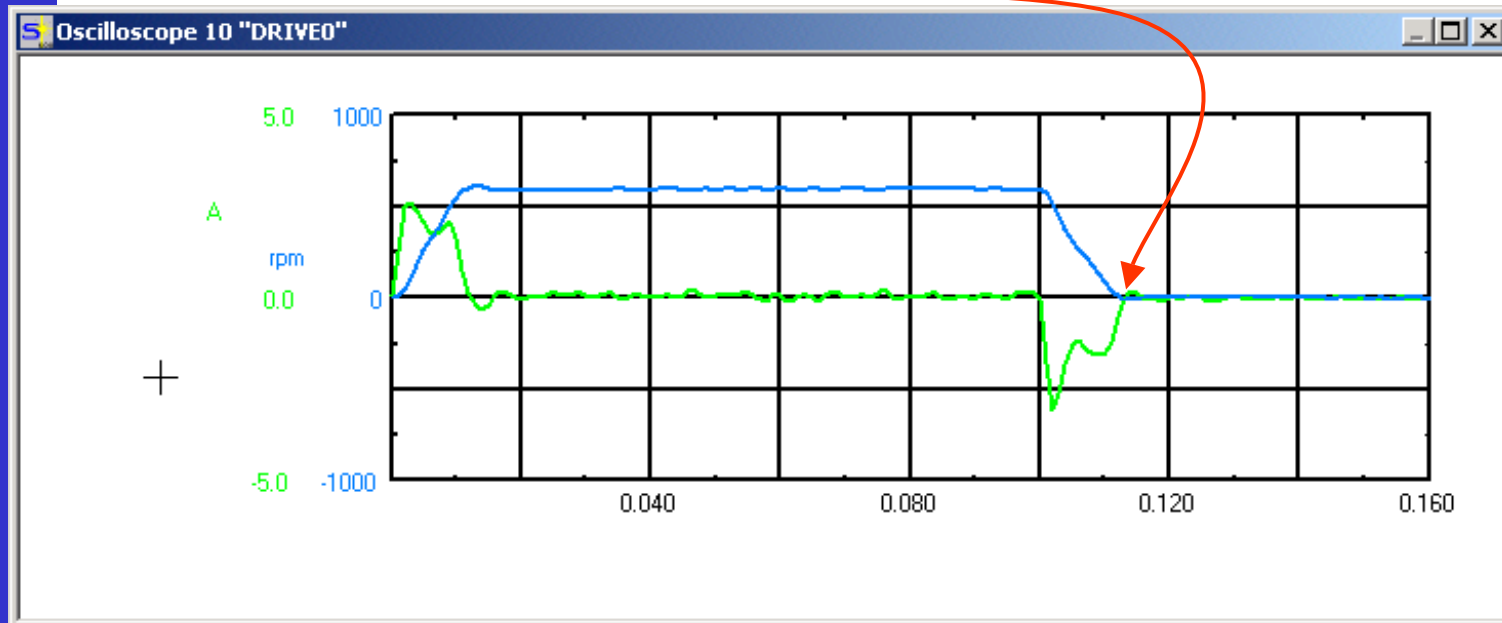
*A mechanically rigid system can respond quickly. This unit responds in under 15 ms with conservative margins of stability.*

## Step 3f

### Set Velocity Feed Forward gain

- To improve command response, increase “Ff factor” to 0.5; lower KV eliminate overshoot. Overshoot is of the most concern when coming to rest.

*Tip: Feed-forward can increase response 20% - 50%. This system responds in about 10ms, about 30% faster with Ff factor = 0.5. However, feed-forward forces KV lower, making poorer response to disturbances like friction; here, KV was reduced 30% (from 0.25 to 0.17) because of overshoot.*



Return...

## Saturation

- Saturation occurs when the current command exceeds the peak capability of the drive. This distorts data and makes tuning more difficult. If your system saturates with a square wave command, reduce command amplitude.

Watch out for saturation at every step of tuning!