PBA Systems Operation Manual

BEI Voice Coil Actuator
with
ELMO HARmonica Driver

Version 1.0
(Preliminary)

Contents

1. Hardware Setup

1.1. Power Supply

HAR requires a +24V DC power supply for the control circuit and DC supply (20 to 180 VDC, depending on HAR model) to drive the motor.

1.2. Electrical Connections

Elmo's digital drives (such as Saxophone, MiniSaxophone and Harmonica) are able to run in 3 different control modes.

1. Analog mode
    - +/- 10 V analog command
    - Current mode or velocity mode

2. Pulse and direction mode
    - Pulse and direction command
    - Position loop closed in driver

3. Standalone mode
    - Software control (position loop closed in driver)
    - Program stored in driver
    - Communicate with other devices through RS232, CANOpen and/or digital I/O
    - Distributed control mode

Notes:
This manual is a simplified version for easy setup of BEI's Voice Coil Actuators with Elmo's digital drivers. For more information, users should refer to the following Elmo manuals.

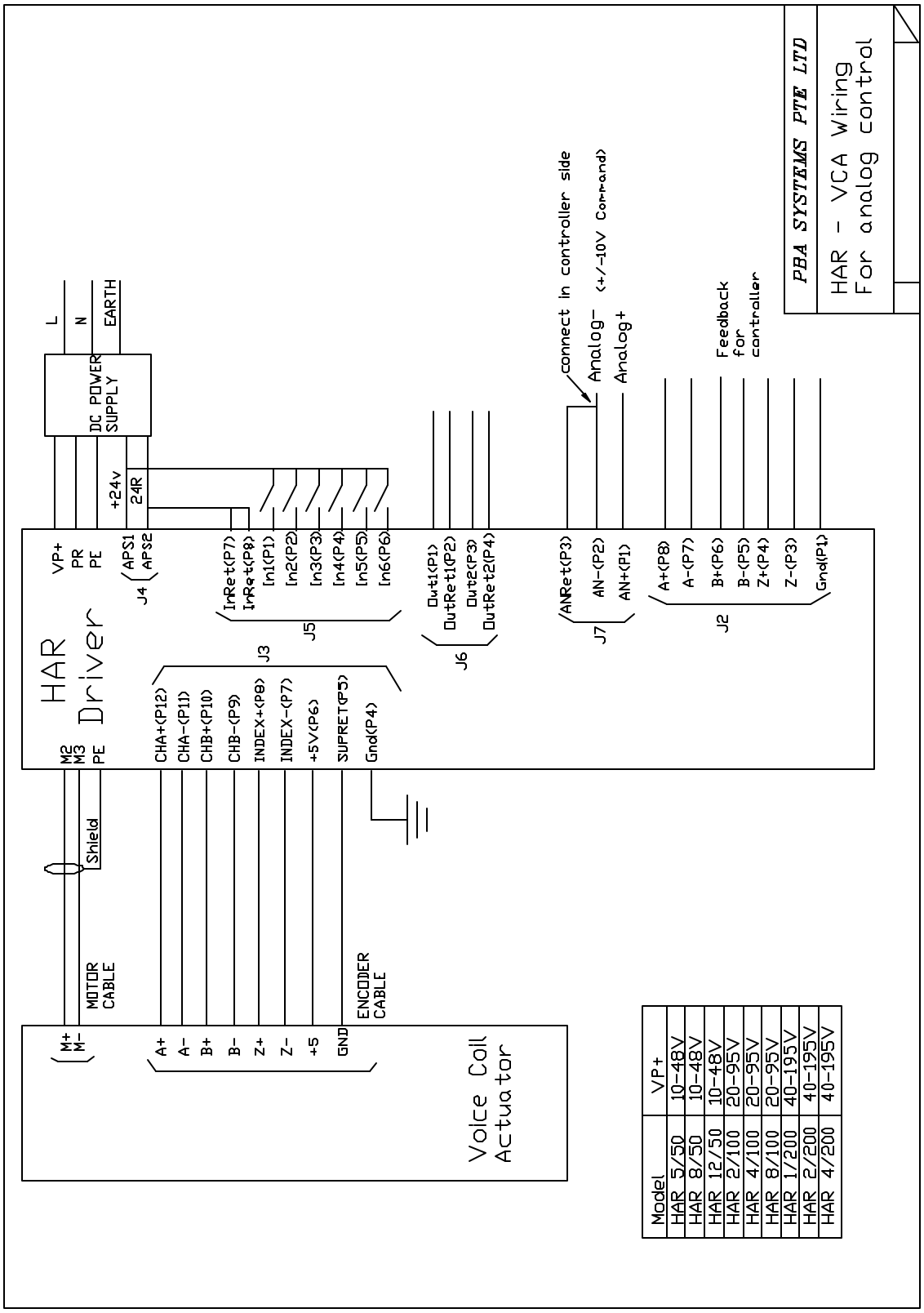
HAR manuals (hardware):

HAR_Cable_Kit.pdf	HAR cable kit manual
HAR_IG_V1.pdf	HAR user guide
HAR_CF.pdf	HAR Command reference manual
HARV1_0_notes.pdf	HAR release notes
HCAN_IG.pdf	HAR CANOpen Implementation guide

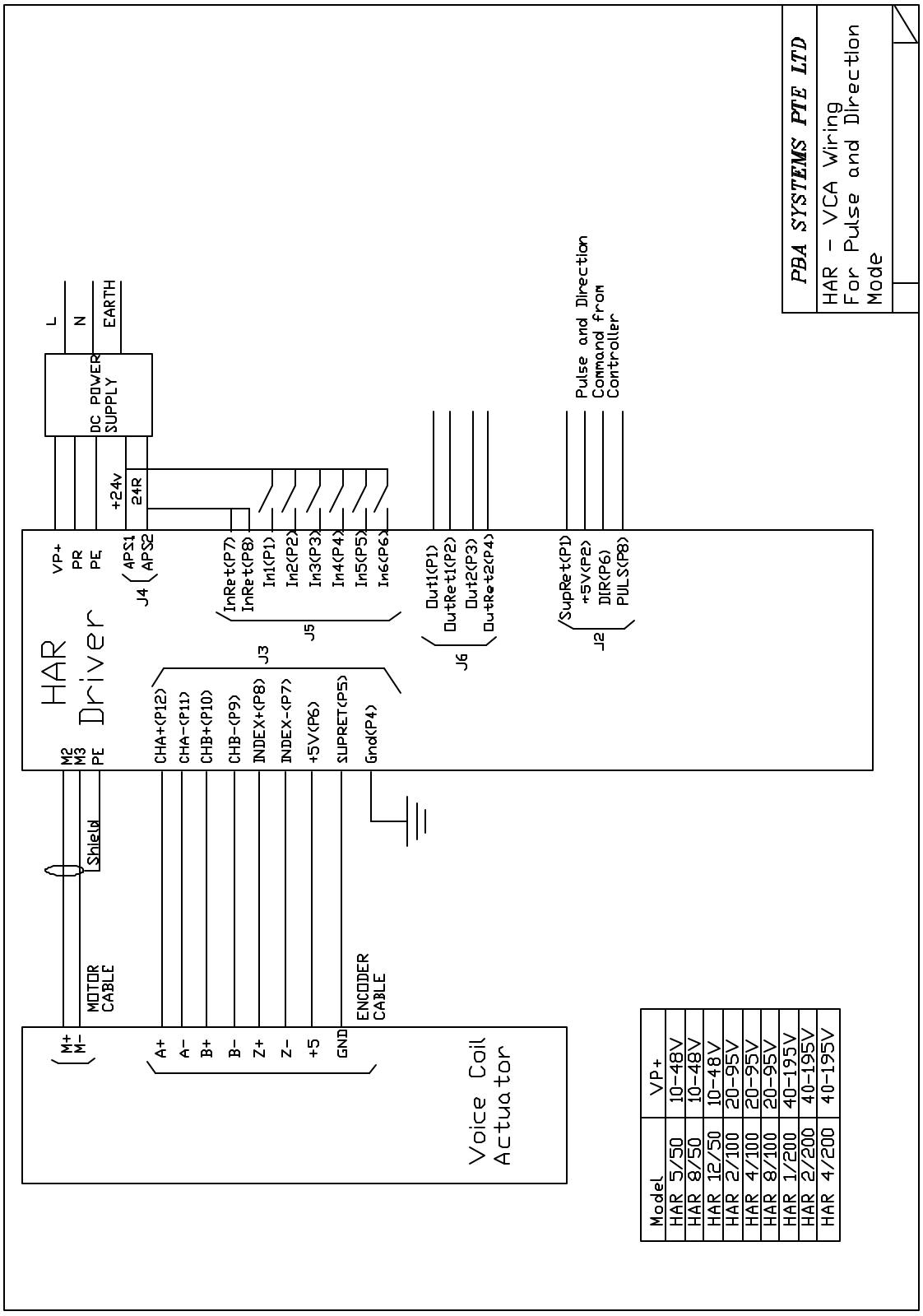
HAR manuals (software):

HAR_SW_manual.pdf	HAR software manual
Composer_SF.pdf	ELMO Composer Software Manual

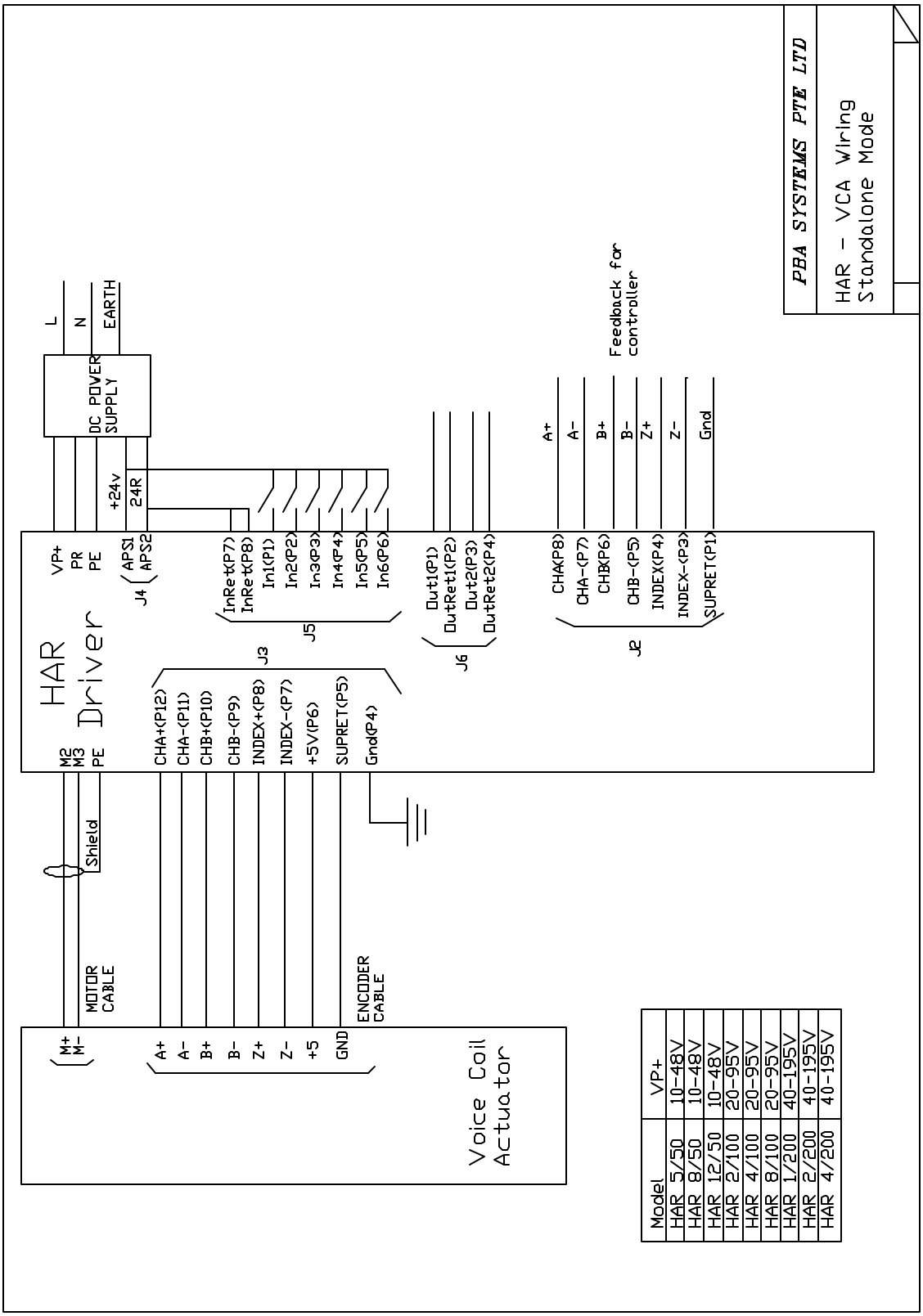
1.3. Analog mode



1.4. Pulse and Direction mode



1.5. Standalone mode



Model	VP+
HAR 5/50	10-48V
HAR 8/50	10-48V
HAR 12/50	10-48V
HAR 2/100	20-95V
HAR 4/100	20-95V
HAR 8/100	20-95V
HAR 1/200	40-195V
HAR 2/200	40-195V
HAR 4/200	40-195V

2. Software Setup

Harmonica drivers (HAR) can be setup using Elmo's **Composer** software. User can download Composer from Elmo's website:
http://www.elmomc.com/products/composer-description-contents-main.htm.

This manual assumes Composer has been installed properly. Please refer to Composer's user manual for installation procedure. This manual uses Composer Version 2.9.0.1 (2 Oct 2003). Some of the screen images may be different if other versions are used.

2.1 Setup Communication

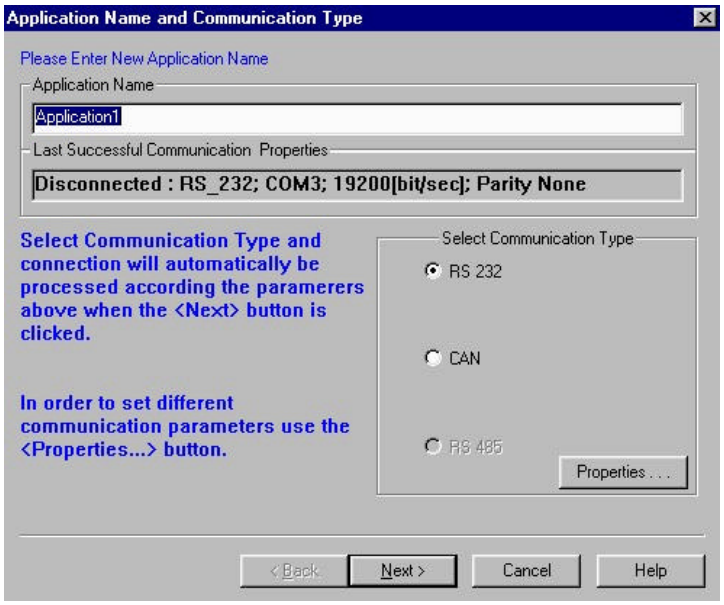
From "Start" menu, select "Programs", run "Composer". The following screen will appear:

Please ensure that the RS232 cable (un-crossed type) is connected from PC to driver.

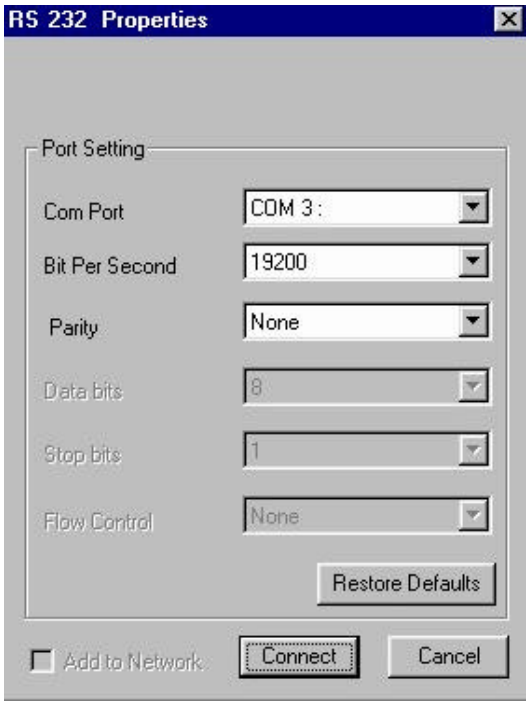
Select "Create a New Application" if you do not have any working application file (.dat files).

Select "Open an Existing Application" if you already have a working copy of the application file (.dat files).

Select "Open Communication Directly" to communicate with driver (bypass setup wizard).

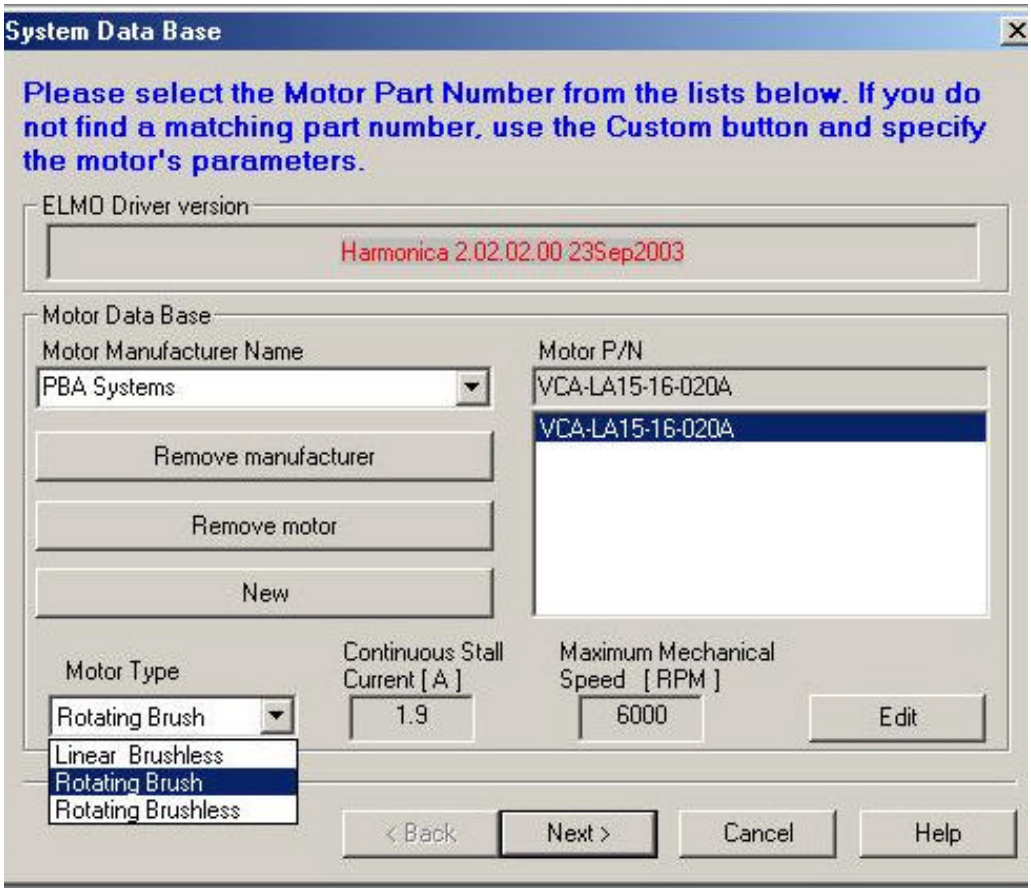


Select RS232 if you are using RS232. (CAN for CANOPEN). Click on "Properties**"** (see below) to change the Com Port (or CAN manager) setting.



Select Com port to use. (Com 1,2 etc). If communication is successful, the following screen (with driver version number) will be shown. If communication is not successful, try another Com port or check your connections (Com 1 or Com 2). Make sure that the 24V is turned ON and Com cable is connected. Note that com cable used is un-crossed type.

2.2 Setup Driver Parameters

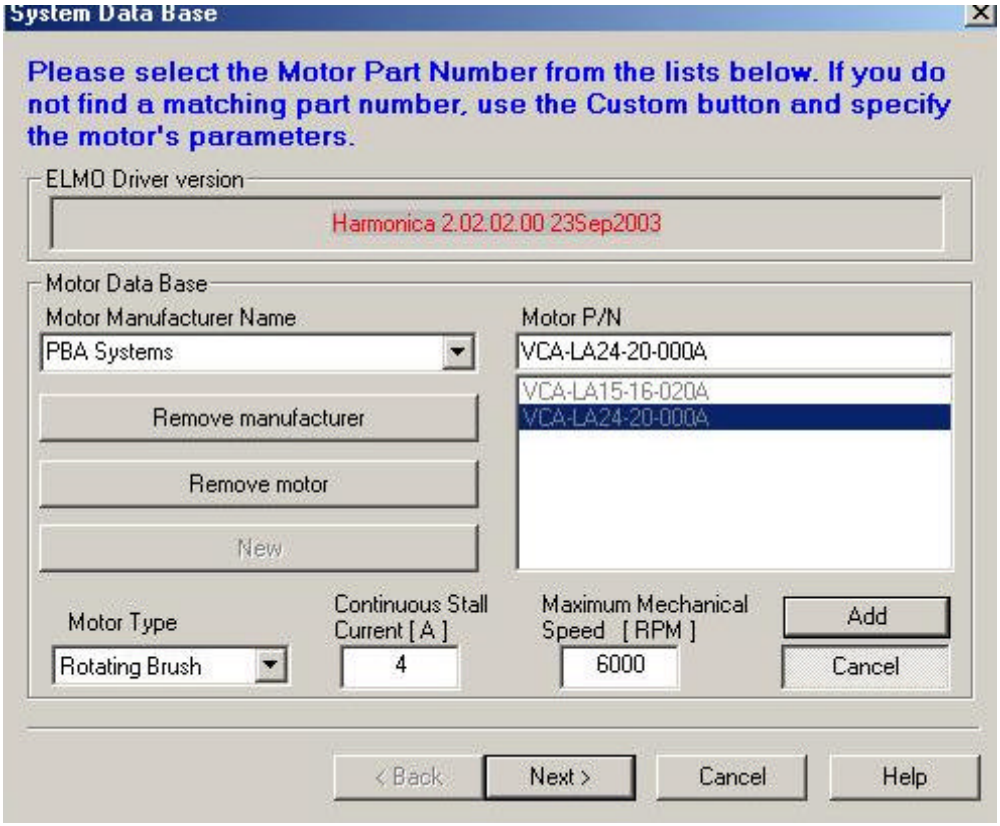


Select **Rotating Brush** for "Motor Type". Note that Composer does not support Voice Coil Actuator directly. However, it is possible to setup a Voice Coil Actuator as rotating brush motor because they are very similar in terms of electrical characteristics.

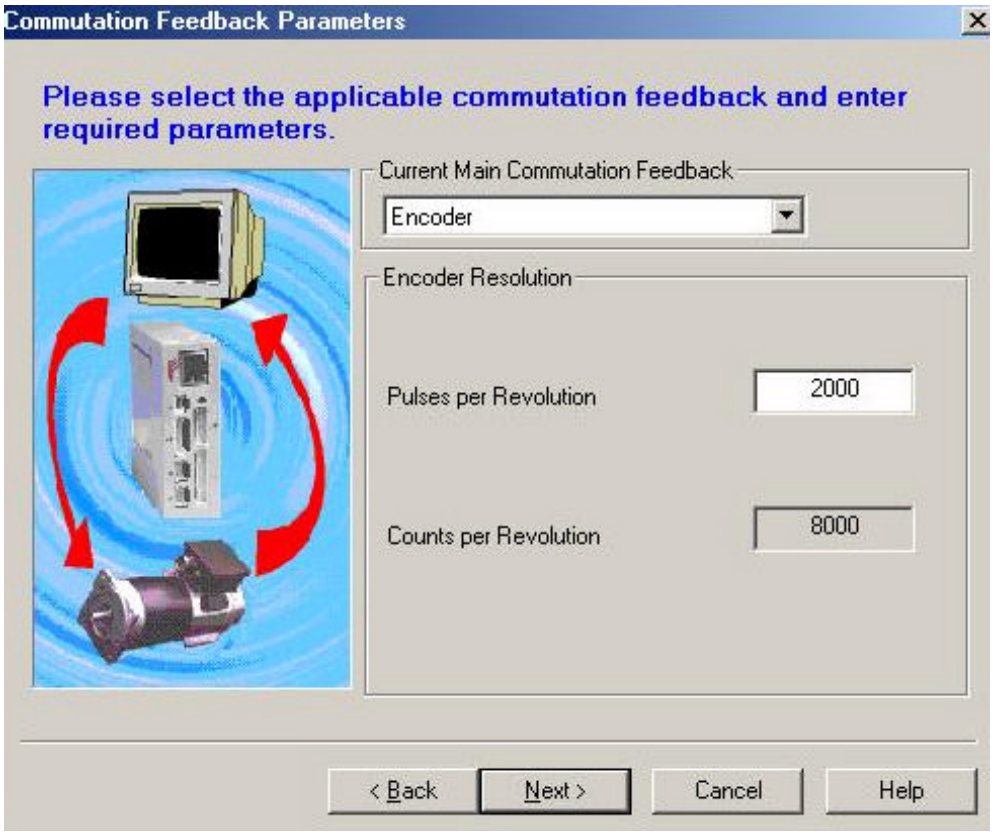
Click on "Edit", change the "Continuous Stall Current (A)" according to the motor specification. Some common BEI's Voice Coil Actuators current specifications are list below. These values are mostly round-downed to a convenient figure and serves as a guideline only. For exact specifications, please refer to BEI's data sheets.

Voice Coil Actuator Model	Continuous Current	Peak Current
LA13-12-000A	0.6	1.5
LA15-16-020A	1.9	5.8
LA15-16-024A	2.2	7.0
LA24-20-000A	4.0	10.0

For “Maximum Mechanical Speed (RPM)”, you may enter 6000. This is equivalent to 100 revolution per second. In the next dialog box, you will need to enter encoder’s resolution in pulse per revolution. Together, these parameters allow the driver to compute the speed limit of this application.

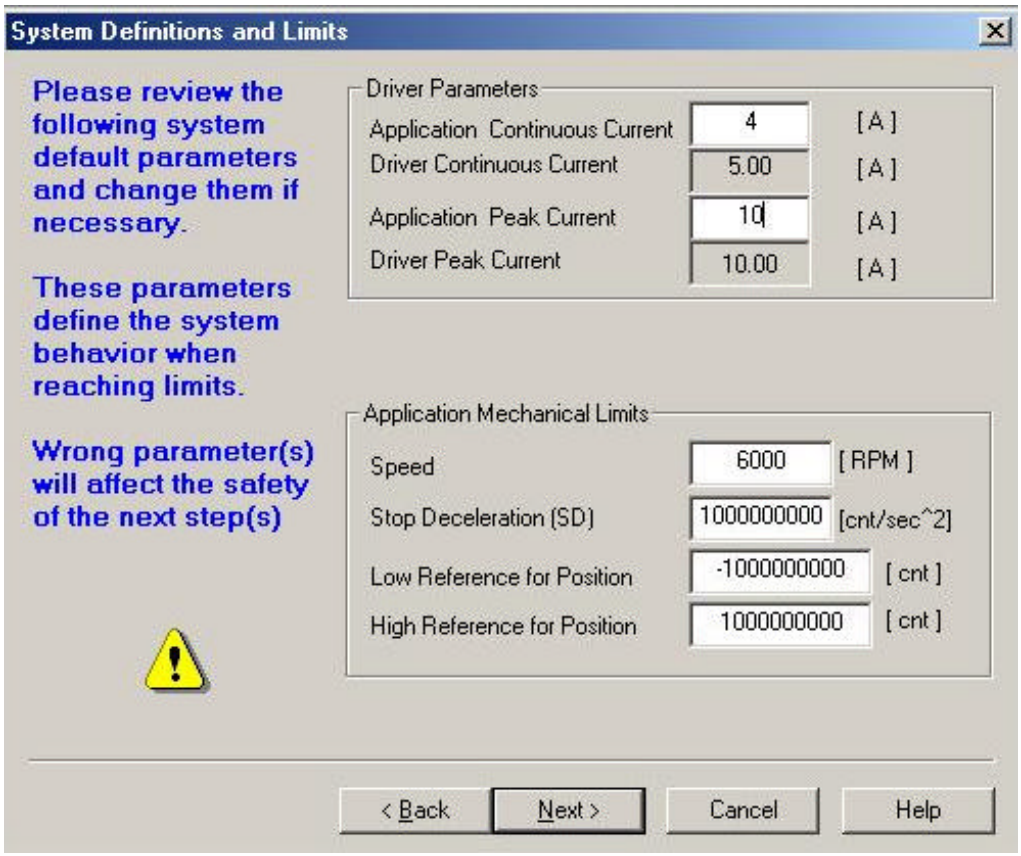


User can choose to assign these setting to a unique Motor Part Number under a Motor Manufacturer Name. This is highly recommended so that you do not need to refer to motor specifications in future when you are going to setup the same motor again.

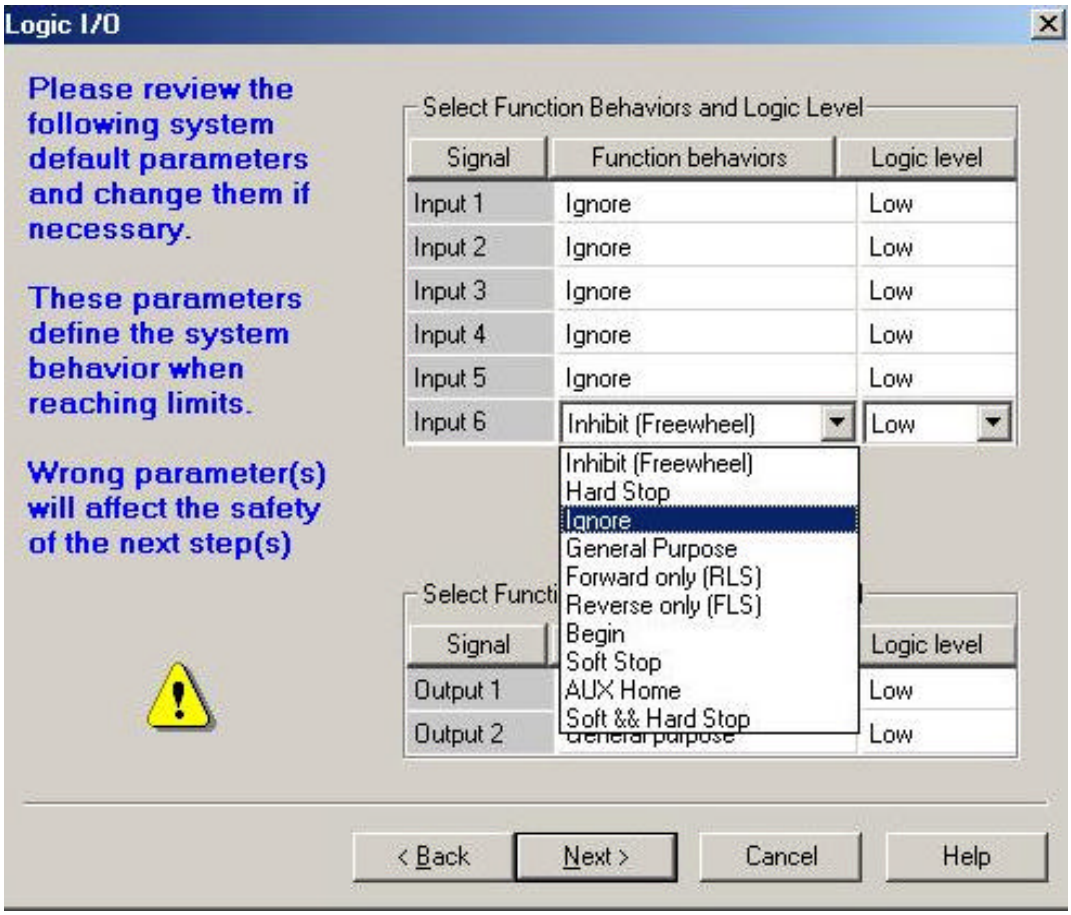


Select **Encoder** as Current Main Commutation Feedback. Enter Encoder Resolution as 2000 Pulse per Revolution.

The software will compute the resolution in counts per revolution (x 4, for quadrature encoder). This result in a maximum speed limit = (6000RPM/60second) * (8000 counts per revolution) = 800000 counts per second. You may want to adjust the 2 parameters to suit your application.



Enter Application Continuous Current, Peak Current and Speed according to the application's need. The application continuous current must be less than continuous stall current entered in the previous dialog box. You may leave the other fields as default.

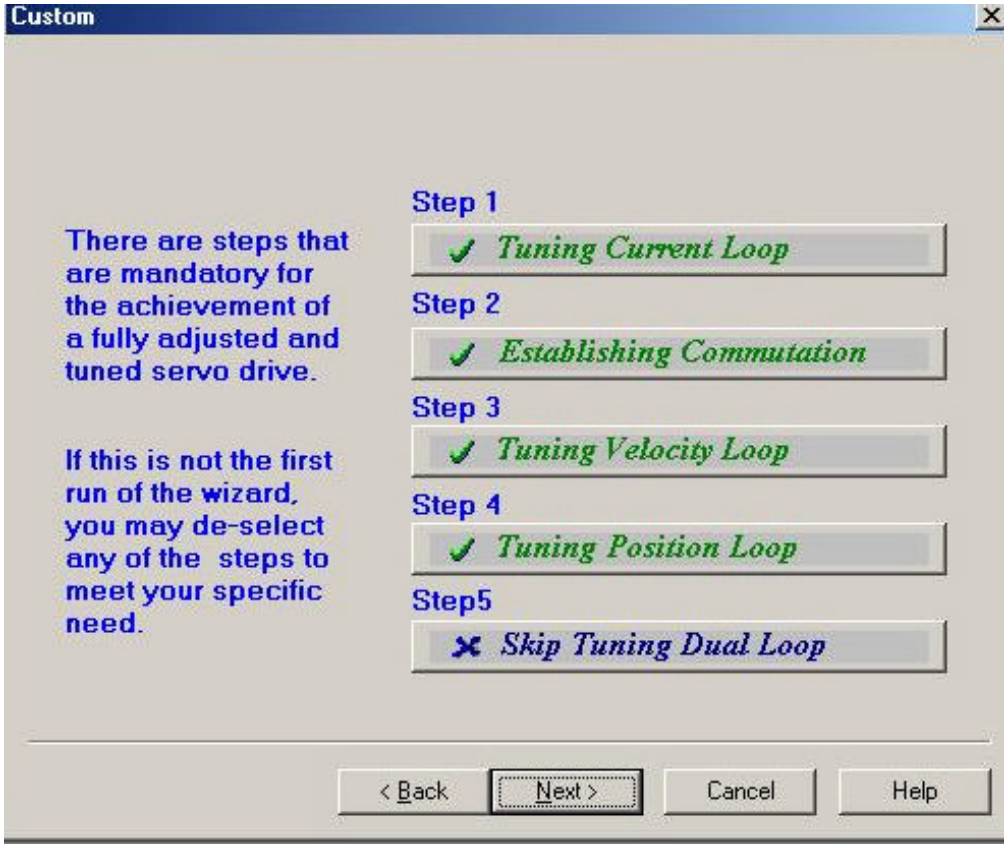


If you have connected inhibit and/or limit sensors input, assign them accordingly (including their logic level). Otherwise, choose "**ignore**" for all the input.

Some common function behavior descriptions:

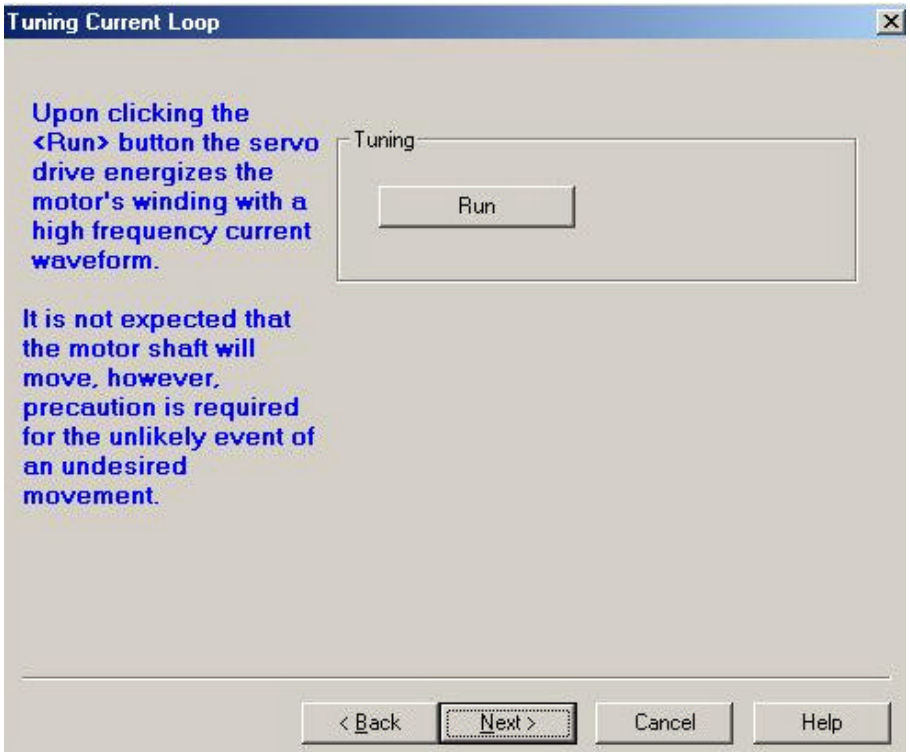
1. Inhibit (Freewheel) - VCA is free to move (servo off) when this input is Active.
2. Forward only (RLS) – This input is connected to Reverse Limit Sensor.
3. Reverse only (FLS) – This input is connected to Forward Limit Sensor.
4. Hard Stop – VCA will stop with maximum deceleration allowed.

2.3 Tuning



- For analog current control mode, only Step 1 and Step 2 are required.
- For analog velocity control mode, Step 1, Step 2 and Step 3 are required.
- For pulse and direction mode, standalone mode and distributed control mode, Step 1, Step 2, Step 3 and Step 4 are required.

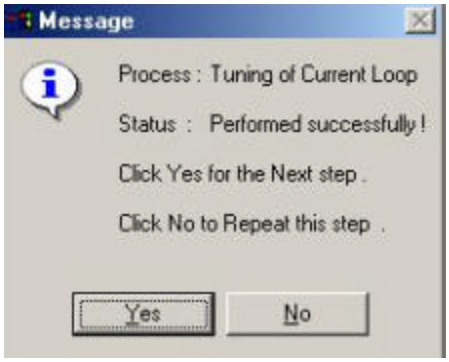
Step 1: Tuning Current Loop



Click "Run" to tune current loop automatically.

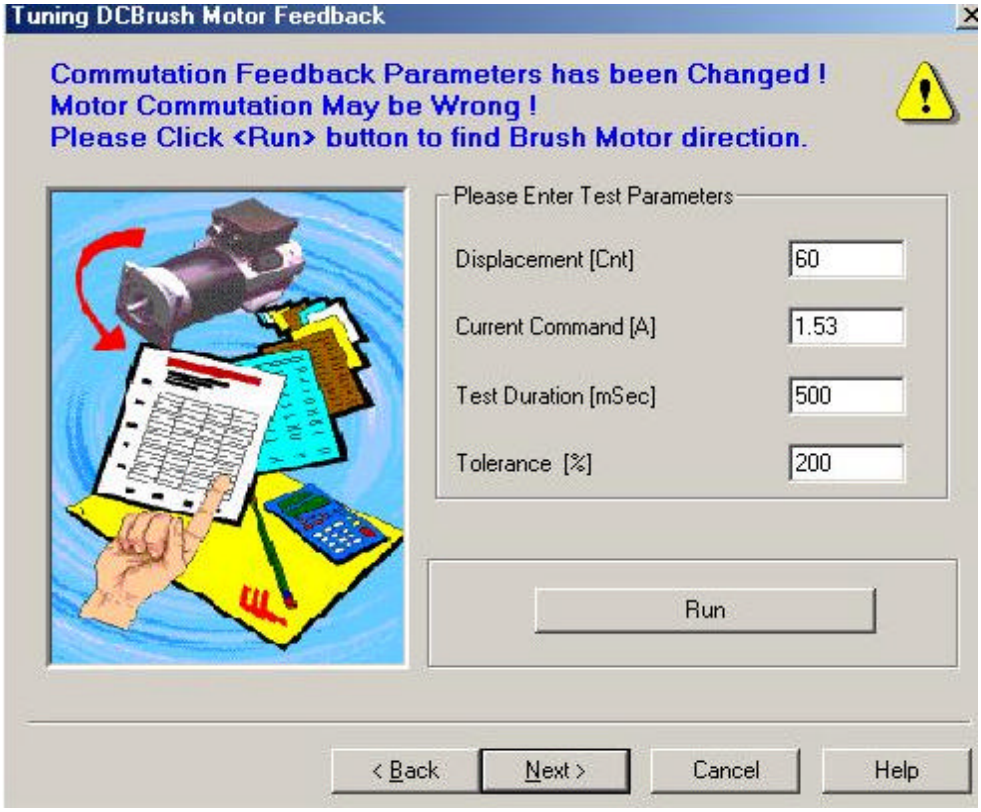
Note:

- If Inhibit behavior is set, ensure that it is NOT at Active state. If unsure, set all input to "ignore" and try again.
- It is possible to tune current loop manually. Press "m" at the above dialog box to access manual tuning dialog box.
- It is not recommended to tune current loop manually unless the auto-tuning result is very bad or cannot be use at all. This is possible for some motors where the inductances are very small. In this case, it will be useful to reduce current loop gains manually.



You should see the above message when tuning is successful.

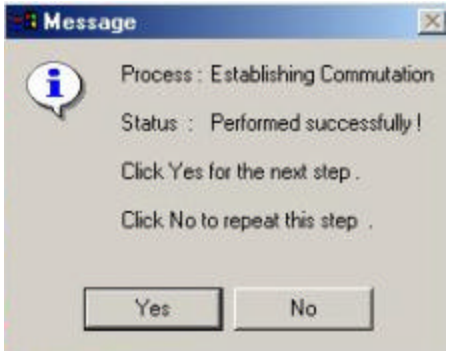
Step 2: Tuning DC Brush Motor Feedback



Before taking the default values and click "Run", ensure that there are enough physical travel distance as required (specified in Displacement (Cnt) field).

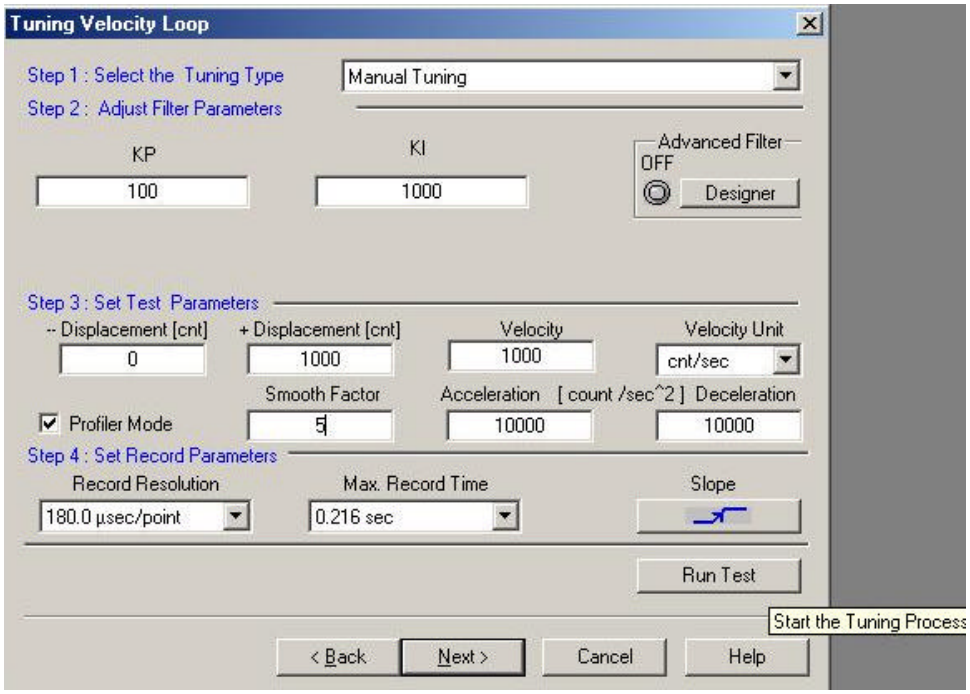
Note:

- This process may fail if the Inhibit, Forward Limit Sensor or Reverse Limit Sensor is Active.
- If unsure, set all input to "ignore" and try again.



The above message box will appear once this step is successfully completed.

Step 3: Tuning Velocity Loop



For Voice Coil Actuator, you should use "Manual Tuning" or "Advanced Manual Tuning". Auto-tuning requires a long travel stroke which usually exceed the physical available stroke for a Voice Coil Actuator.

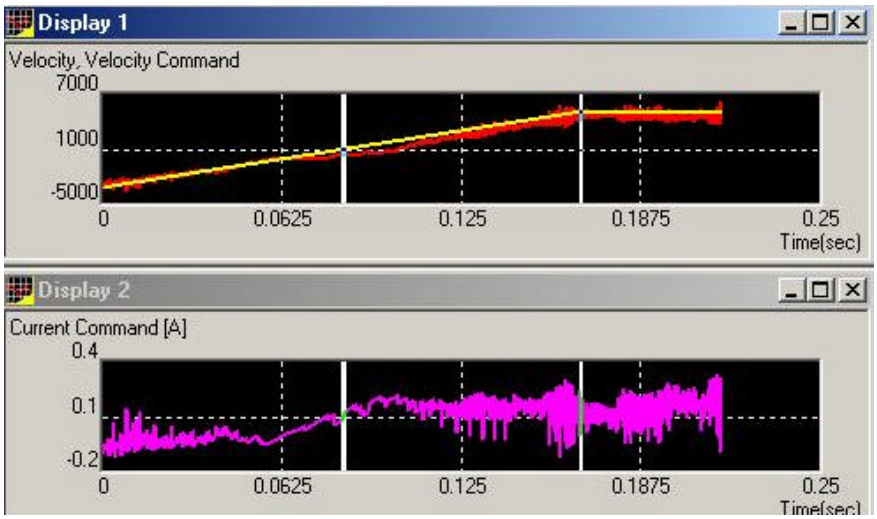
Set "- Displacement" and "+ Displacement" at least 20% smaller than the available stroke to allow overshoot during tuning. During tuning, the actuator will cycle in positive and negative direction repeatedly. Hitting the hard stopper will yield inaccurate result. Velocity and Acceleration/Deceleration settings should also start from small values.

Start with small KP (e.g. 1) and KI (e.g. 10). If the actuator doesn't move at all (the data acquisition message window will wait forever for the triggering event), cancel the data acquisition process and increase KP and KI.

Typically, KP is around 100 and KI is around 1000. However, these parameters vary with different loads and motion profiles. During the tuning process, the Voice Coil Actuator may oscillate vigorously. Make sure the actuator is mounted firmly on a rigid frame. You may cancel the tuning (click "Cancel") before the motion stops and try again with smaller KP and/or KI.

Click "**Run Test**" to start the test motion and data acquisition. A graphical display (scope) will appear once the data acquisition is completed. User can zoom in/out, drag the primary cursor to check the instantaneous data (showed in the status bar).

Re-iterate KP and KI until the result is acceptable. Click "Next" only when you have found the optimal KP and KI values.

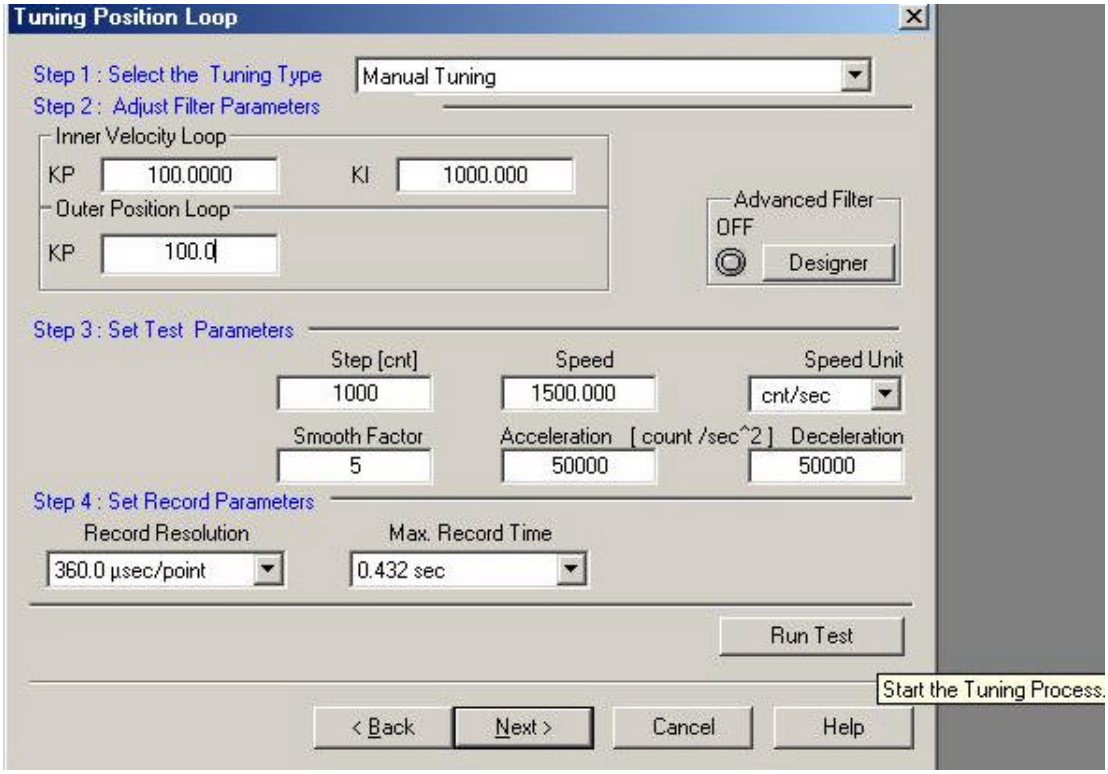


After each iteration, the above scope will appear. Typically, velocity loop doesn't require very good following performance and usually an overshoot is allowed to ensure fast response in the position loop.

If the performance is no good with manual tuning, user can choose to select "Advanced Manual Tuning". Elmo's digital drives have a gain scheduling algorithm built in where the driver can switch KP and KI automatically according to the travel velocity.

In Advanced Manual Tuning, there are a maximum of 64 sets of KP and KI. User can choose to manual tune all 64 sets of gains or tune a few sets of KP and KI, and let the software interpolate the rest. Refer to ELMO's manual (Composer user guide) for more information.

Step 4: Tuning Position Loop



Similar to velocity loop, position loop for Voice Coil Actuator should be tuned manually (Manual Tuning or Advanced Manual Tuning).

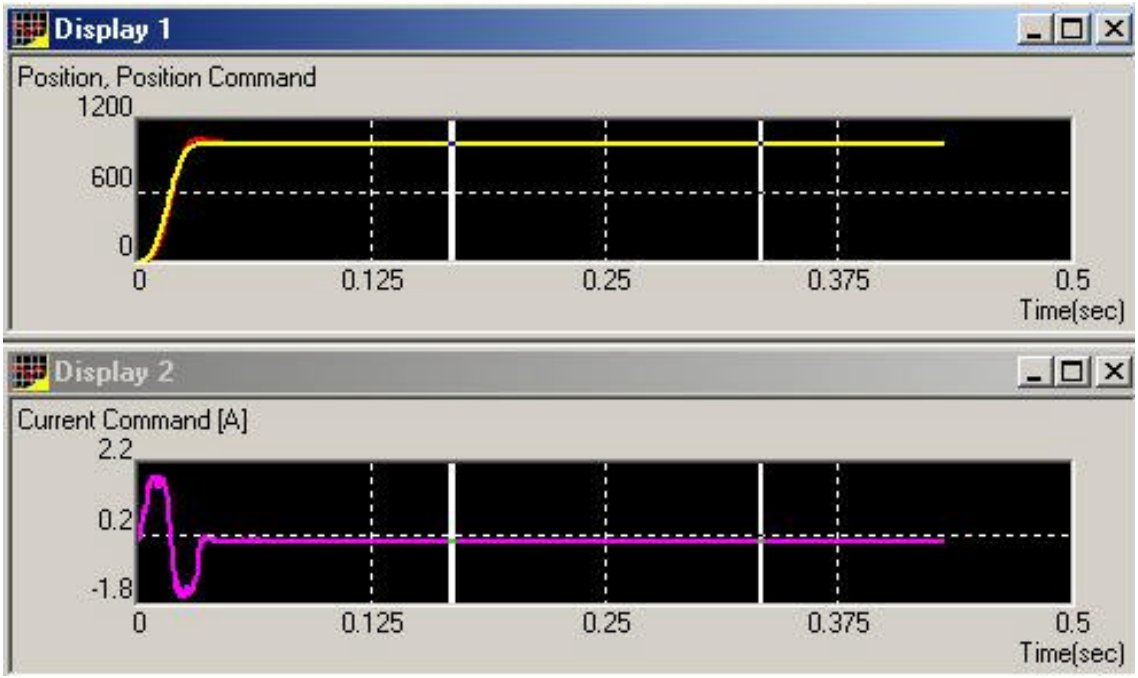
Set "Step" (travel displacement) according to the required travel distance. Speed and Acceleration/Deceleration setting should eventually set to the required values to test the actual operational performance. However, it is advisable to start from slow speed and low acceleration to avoid excessive overshooting and oscillation when KPs and KI are far from optimized.

Click "**Run Test**" to start motion and data acquisition.

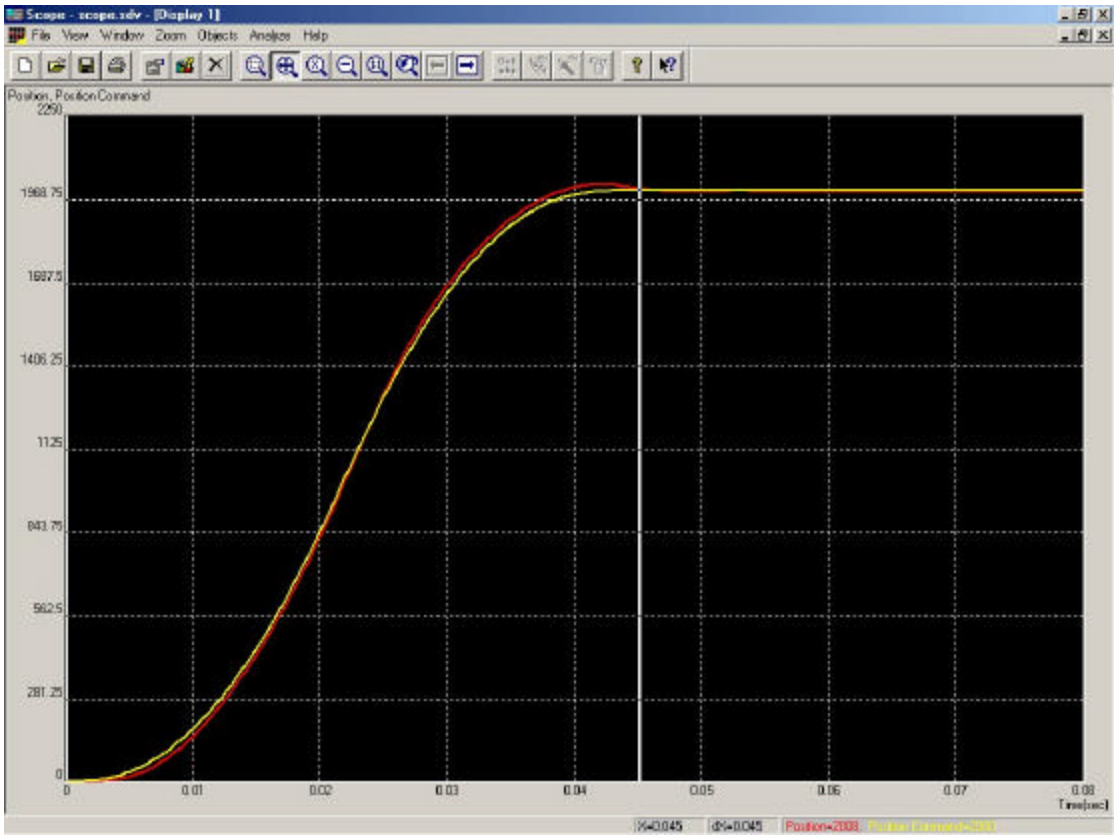
Iteration of Position Loop KP is required to optimize the performance. User are allowed to modify the Velocity Loop KP and KI if necessary.

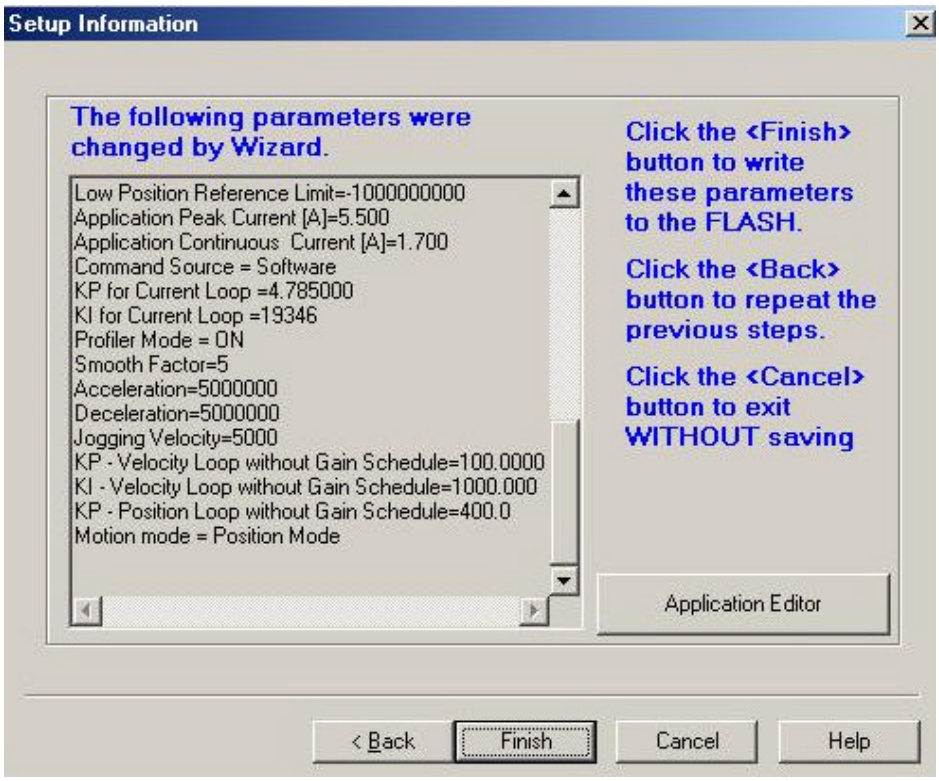
Again, if the performance is not ideal, user can choose to tune in "Advanced Manual Tuning" mode to modify 64 sets of control gains at different velocity. Refer to ELMO's Composer User Guide for more information on Advanced Manual Tuning.

Click "Next" after an optimized set of control gains are obtained.

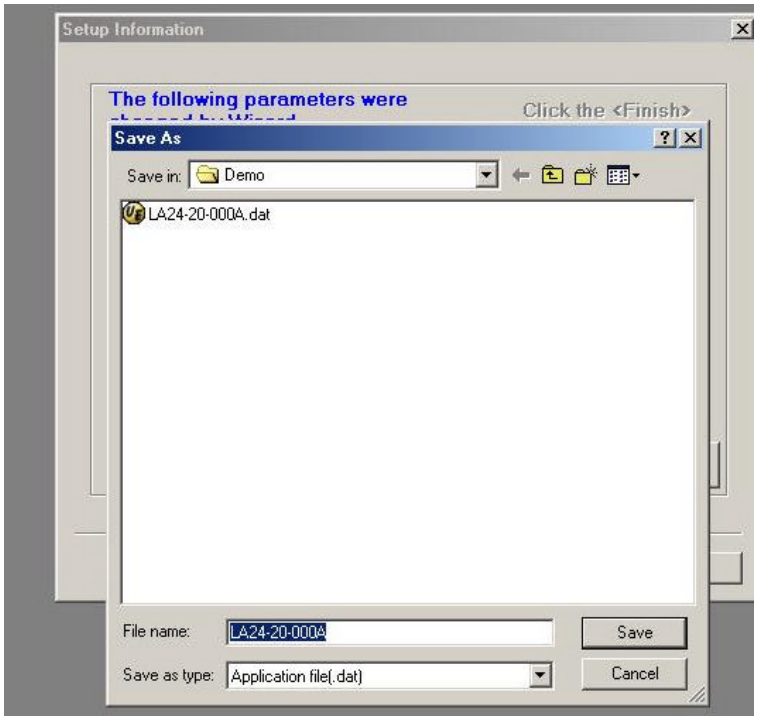


After every iteration, the above scope will appear. User can zoom in/out the graphs and drag the primary cursor to different position to check the instantaneous data (showed in the status bar). An example of zoomed in graph is shown below. Note that dX value showed in the status bar is the time difference between the 2 cursors.

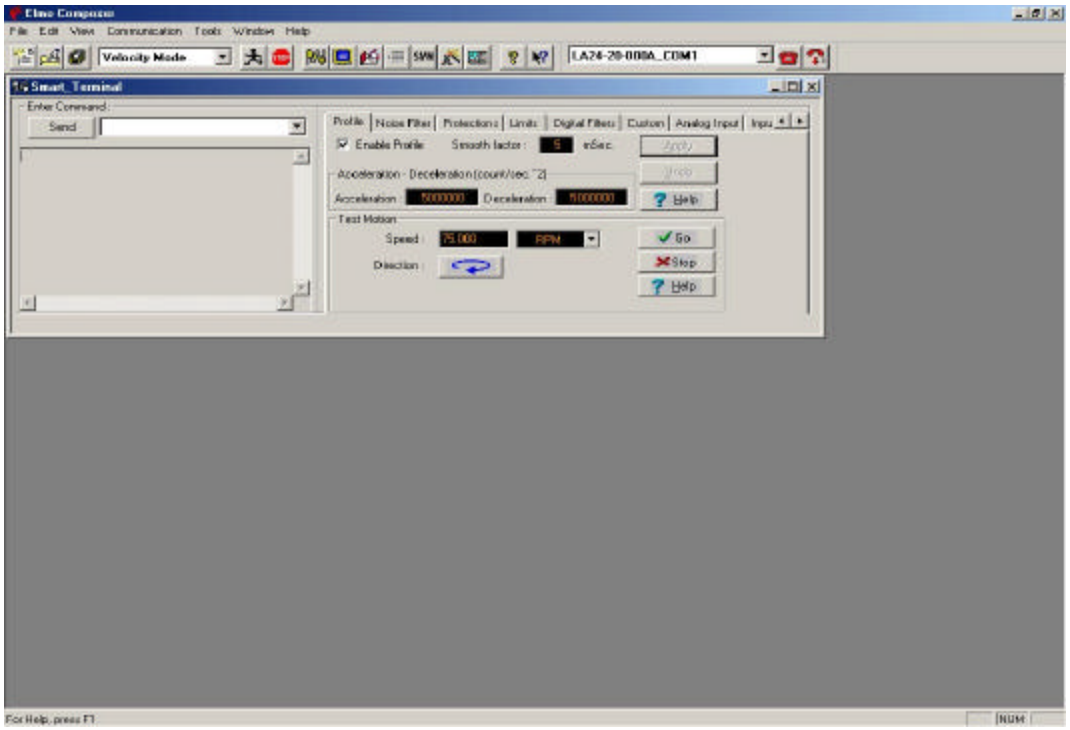




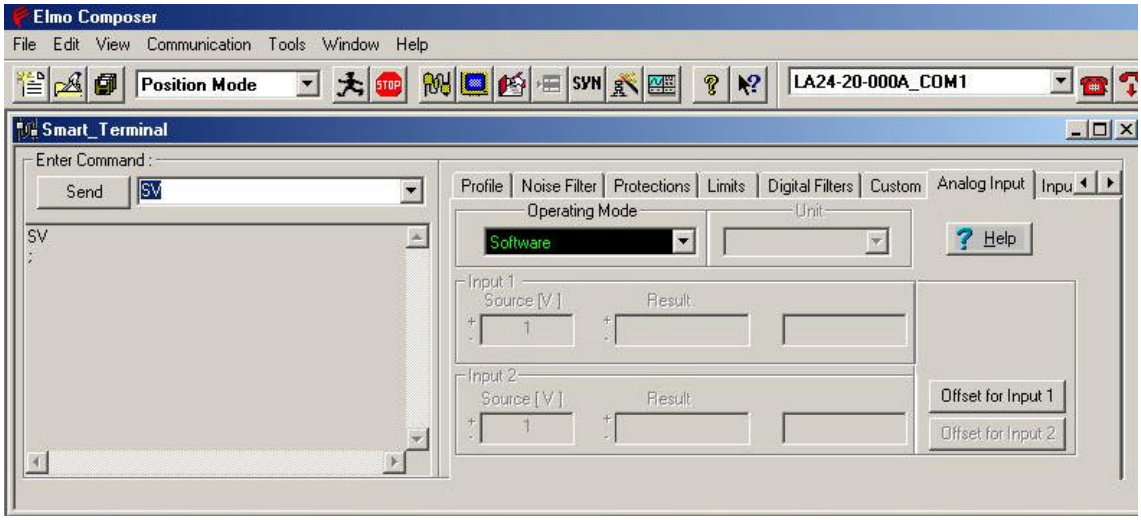
Finally, a summary of all parameters will appear. Click “Finish” to continue.



User will be prompted to save the application data.



The “Smart Terminal” will appear.

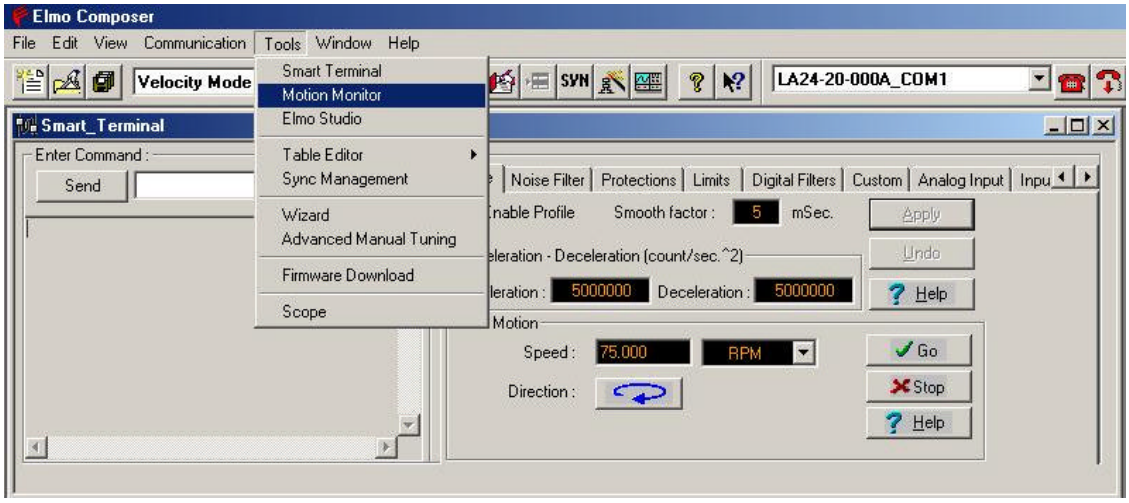


To save all parameters to the non-volatile memory in the driver, type “**SV**” in the “Enter Command” field and click “Send”. You should see an echo of “SV” followed by a semicolon, “;”, if the command is executed correctly.

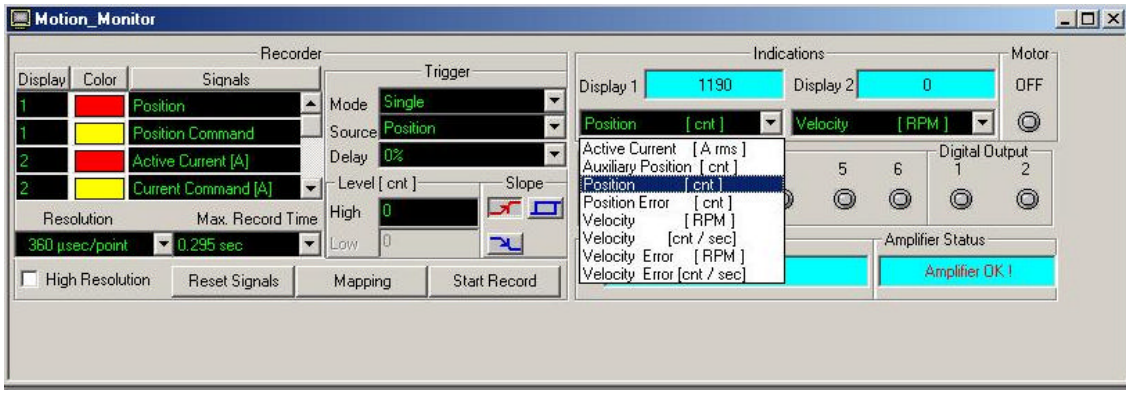
Before saving to non-volatile memory, any loss of power (24V auxiliary power supply) will result in **loss of all settings and tuning data**. User will have to re-do the whole process again. Hence, it is important that this step is not missed and should be done as soon as possible.

3. Diagnostic and Troubleshooting

There are very good diagnostic and troubleshooting tools available in Composer. This section briefly introduces some commonly used features in Motion Monitor.

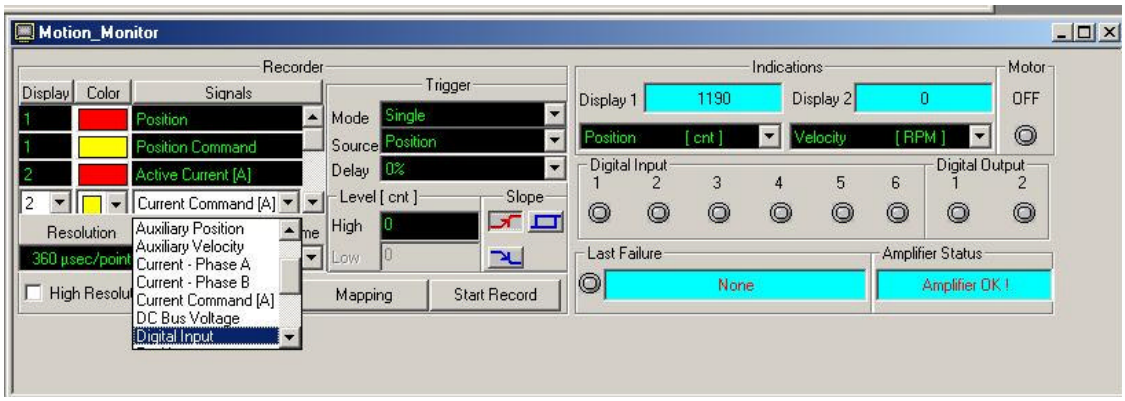


Select “Tools” from the menu bar, click “Motion Monitor”.



Motion Monitor Window will appear. On the right hand side of the window, there are 2 display fields, “Display 1” and “Display 2”. They are updated continuously. User can pull down the list to select a data source to display here.

Below the 2 displays, there are digital I/Os indication and Amplifier status.



On the left hand side, there is a “Recorder”. It behaves like an oscilloscope. User can choose to record various data in one or more graphs. If the required data source is not in the pull down list, click “Mapping” button to re-map the data sources.

After selecting the data sources to capture, there is a choice of data resolution. The better the resolution, the shorter the record time.

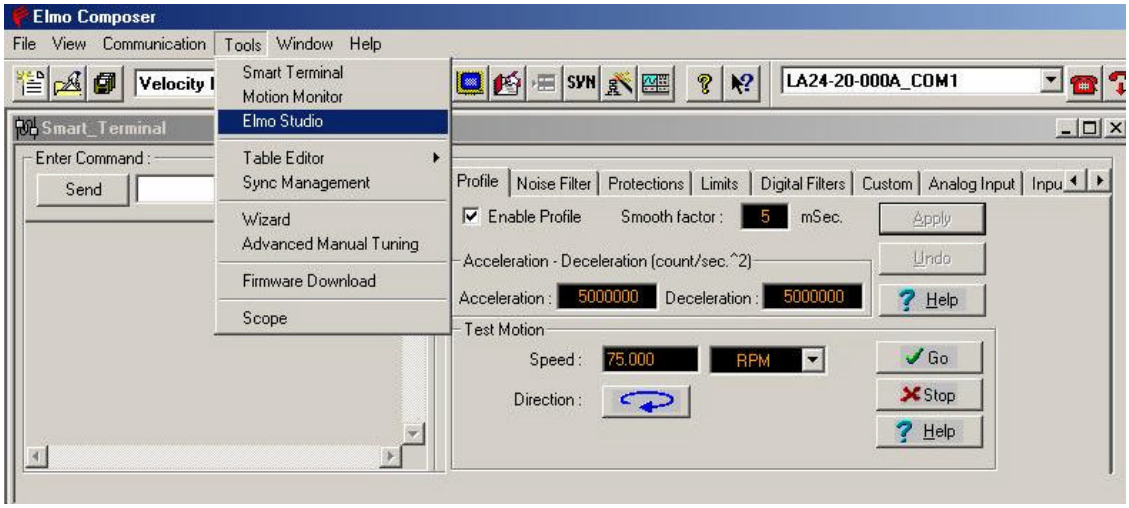
Next, select the trigger mode. Typically, “Single” is selected (record on the first trigger event). Delay can be set so that data before the trigger event are recorded. For example, if “Delay” is set to 50%, then half the recorded data are before the trigger event.

The trigger source is usually one of the data source to record (but not necessary). User must define rising edge, falling edge or both in the “Slope” setting. For example, if Position is chosen as the trigger source and under “Level (cnt)”, High is set to 100, with the rising edge button selected, then the recorder will start recording when actual position crosses 100 counts in the positive direction.

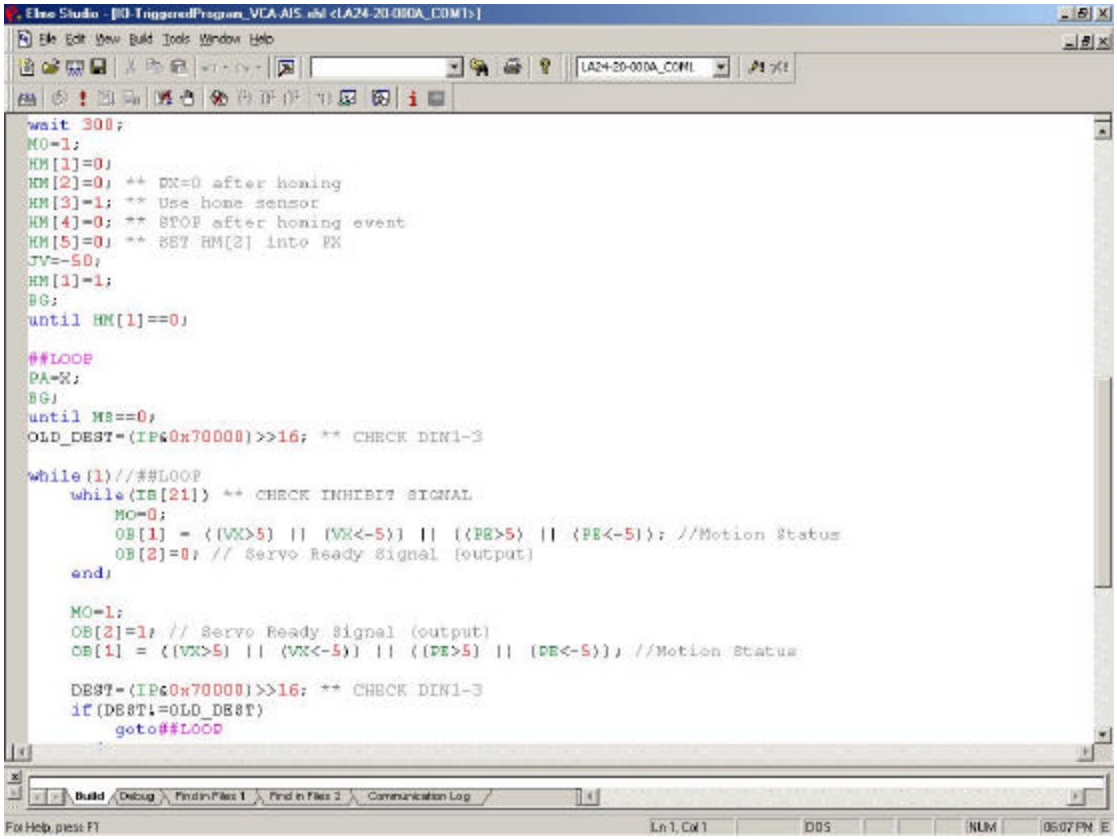
With these functions, user can monitor encoder signal, analog input commands, motion profile (actual and commanded), etc. Motion time can also be measured from the graphs.

For more detailed explanation of these functions, refer to Elmo’s Composer User Guide.

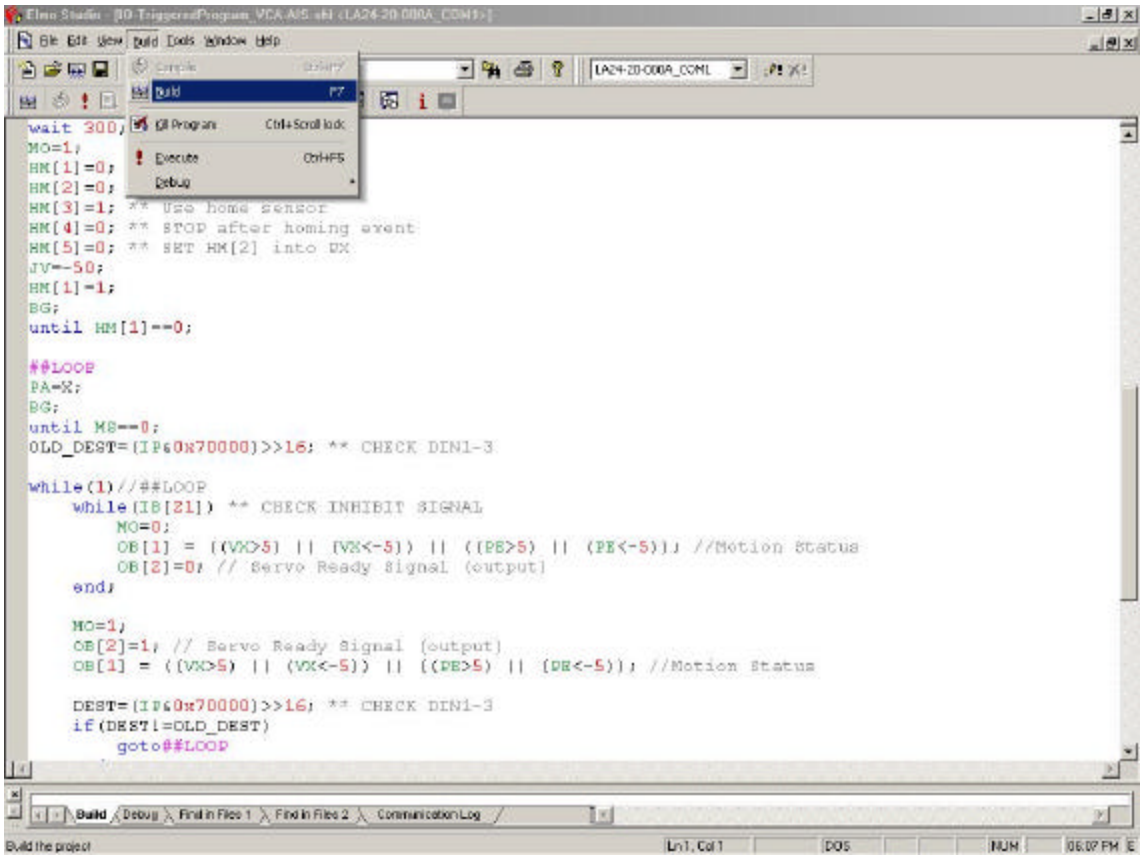
4. Programming



To enter Elmo's programming environment, select "Tools" from menu bar, click "Elmo Studio".



The Elmo Studio editor will appear. For details of Elmo's programming languages, refer to Elmo's manual (http://www.elmomc.com/support/manuals/HAR_SF_0903.pdf).



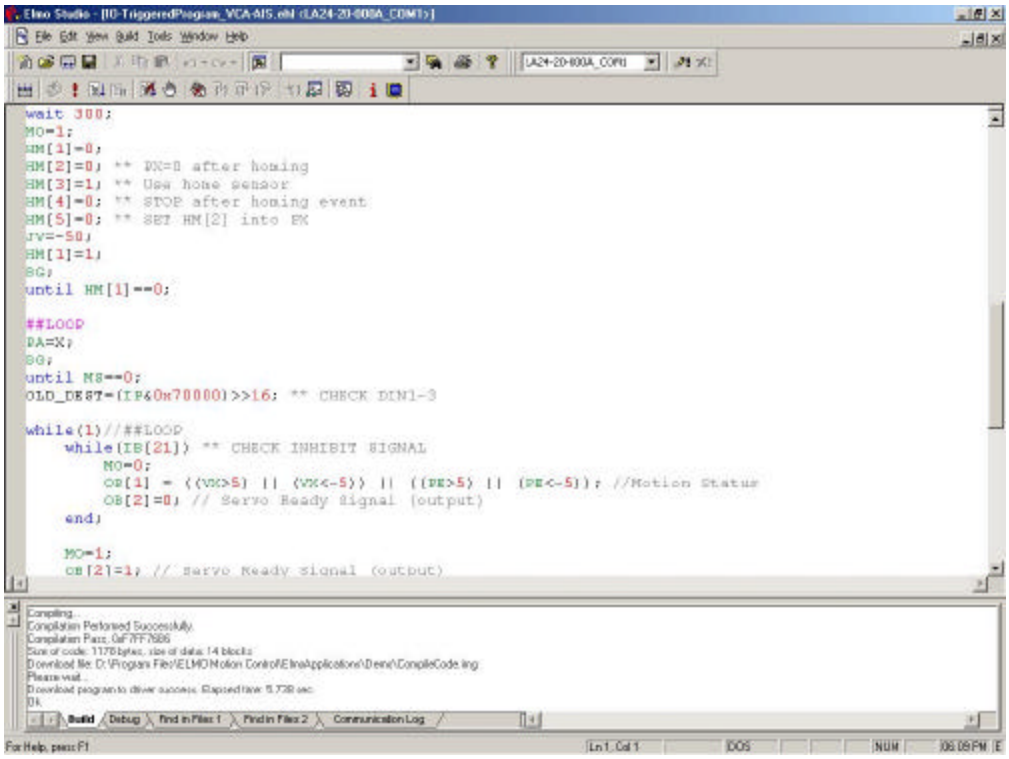
An example of Elmo's High Level program is below:

```
#@AUTOEXEC
SP=1000; // speed = 1000 counts/sec
AC=10000; // acceleration = 10000 counts/sec2
DC=AC; // deceleration = aceleration

wait 300; // wait for 300ms
MO=1; // turn on motor (servo on)

while(1) // infinity loop
     PA=5000; // Move to 5000 (absolute position)
     BG; // Begin move
     wait 2;
     until MS==0; // Wait for motion completion
     wait 500; // Dwell for 500 ms
     PA=0; // Move to 0 (absolute position)
     BG; // Begin move
     wait 2;
     until MS==0; // Wait for motion completion
     wait 500; // Dwell for 500 ms
end;
```

After writing the program, user has to build and download the program into the driver. Select “Build” from menu bar and click “Build”. It will compile the codes and download to the driver if compilation is successful. This will take a few seconds.



The program can be executed from Elmo Studio, or if there is a #@AUTOEXEC label in the program, it will start automatically from that line when the driver is powered up.