Using PI DC-Servomotor Stages and Actuators with National Instruments' Controllers

Abstract

NI's PCI motion controllers are popular and offer good performance and superb software at a price commensurate with other popular motor controllers from Galil, Delta Tau, MEI/Danaher and Tech80/ACS. Consequently, they are frequently specified by customers, especially LabVIEW users.

PI developed the C-809.40 amplifier/interface for use with NI DC-motor controllers and PI DC servo stages and actuators. This unit is suitable for use with all PI DC Servomotor stages and actuators. Standard PI motion cables connect up to four devices to the C-809.40. One C-809.40 may be used with NI's PCI-7340 and 7350 Series motor controllers for up to four axes. Two C-809.40s may be used with NI's 7358 eight-axis controller. An NI SHC68-C68-S cable connects each C-809.40 to the motion connector on the NI controller. (Note that the controller's motion and digital I/O connectors are identical. Be sure to connect the C-809.40 to the motion connector!) C-809.40 is not compatible with NI's 7330 stepper-motor controller or 7390 controller for pulse-command drives.

Setup

Each axis of the 4-axis bank of NI 7340/7350-Series controller to which the C-809.40 is connected needs to be configured for analog servomotor control. In addition, the limit and home switch logic for the PI stage must be set correctly, and the servo gains must be set for safe and responsive operation.

In this TechNote we document the most aggressive settings we recommend for use with a variety of unloaded PI stages. Depending on your load and dynamical requirements, you may need to modify these settings. In addition, it is possible that your PI stage may require different limit or home logic than is documented here; for example, as part of PI's continuous-improvement process we have added home switches to some of our products which formerly lacked them. Please consider the settings documented here as starting points for getting your system running crisply and stably, but expect to perform some optimization on your own. Be sure to initialize the controller with your new settings.

The settings documented here allow the controller to drive up to four axes (7340 Series) or eight axes (7350 Series) with a servo update rate of 250µsec. Faster servo rates are possible if you disable some of your controller axes, but in our testing we saw no significant improvement in performance. If you use a servo update rate other than 250µsec, the settings documented in this TechNote will not apply.

The NI controller's settings are established by using the NI-MAX (Motion and Automation eXplorer) software utility, which is installed from the NI software CD.

Incidentally, NI-MAX offers an auto-tune capability which results in safe gains with reasonable performance about 80% of the times we tried it. As with virtually all automated tuning utilities, a moderately skilled operator will be able to achieve much better performance by optimizing the PID settings manually.

The NI-MAX Axis Configuration Pane

After entering NI-MAX, find the motion controller in the *Devices and Interfaces* tree, and expand the listing. By selecting (highlighting) the *Axis Configuration* heading (), you can make global changes to all axes. Or, expand the *Axis Configuration* heading to reveal the individual axes.

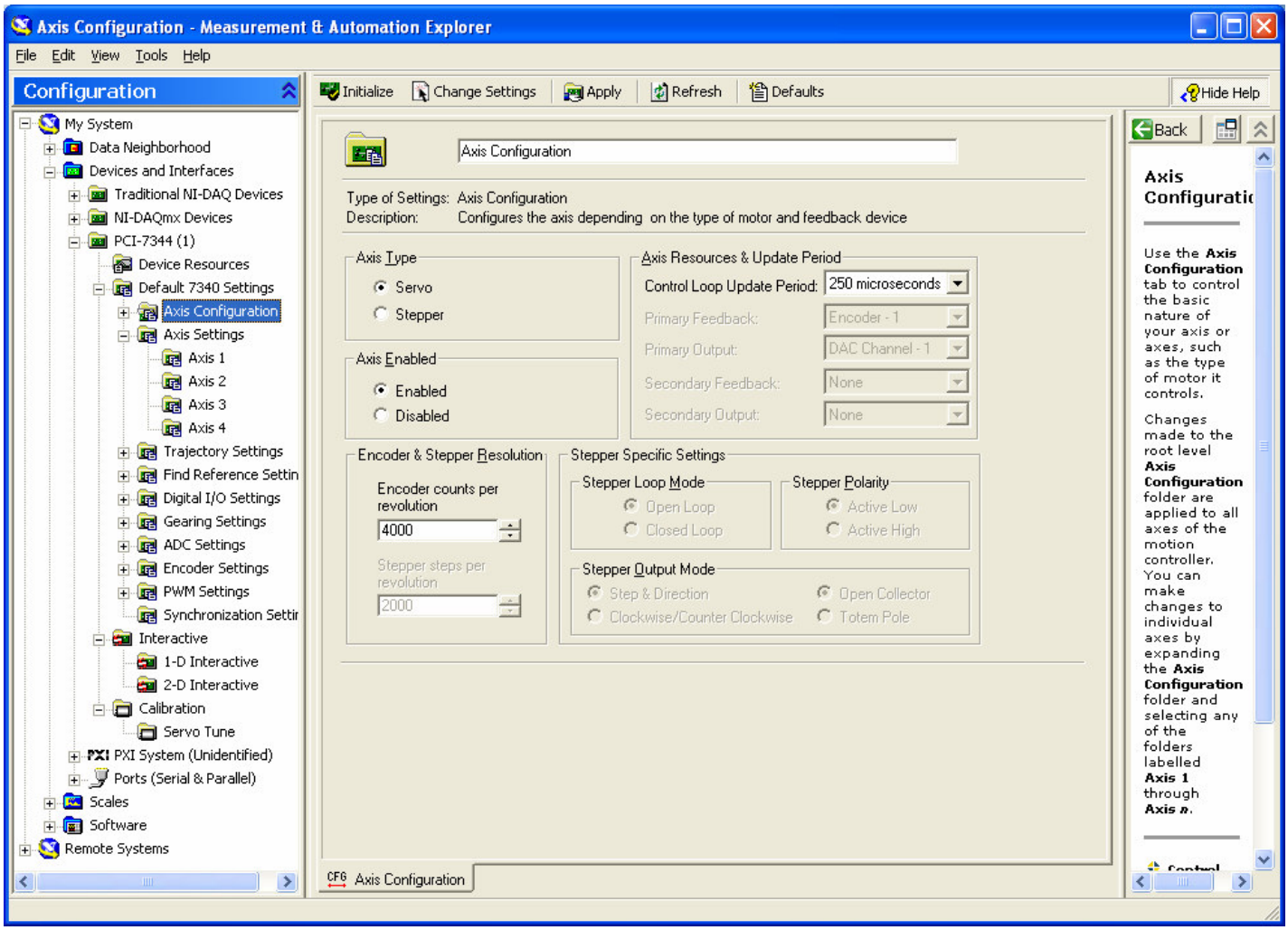

Figure 1. NI-MAX Axis Configuration screen.

- Important: Set the *Axis Type* to Servo for *all* axes in the bank of 4 axes connected to C-809.40. This drive/interface box supports only PI DC servomotor devices.
- For rotary motor devices, consult your PI motion devices' documentation for the *Encoder Counts Per Revolution* parameter.
- Important: If you wish to use the settings documented in this Tech Note, set the *Control Loop Update Period* to 250µsec.
- Click the *Initialize* button to download these new parameters to the NI controller.

The Axis Settings pane: Switch Logic settings

This pane is where you set limit logic, enable home switch, etc., for each motion device connected to the C-809.40. There are also tabs at the bottom of the pane for navigating to the servo-loop gain settings controls.

The switch logic settings shown in Figure 2 worked for each of the PI motion devices we tried. It is possible that your particular device might have different switch logic. You can determine the correct settings by moving the stage (manually, ideally) while monitoring the limit and home switch indicators in the *1-D Interactive* pane.

Soft limits are an optional capability of these controllers. Refer to the NI documentation on their use.

The Inhibit Output settings shown in Figure 2 should work with all devices connected to the C-809.40.

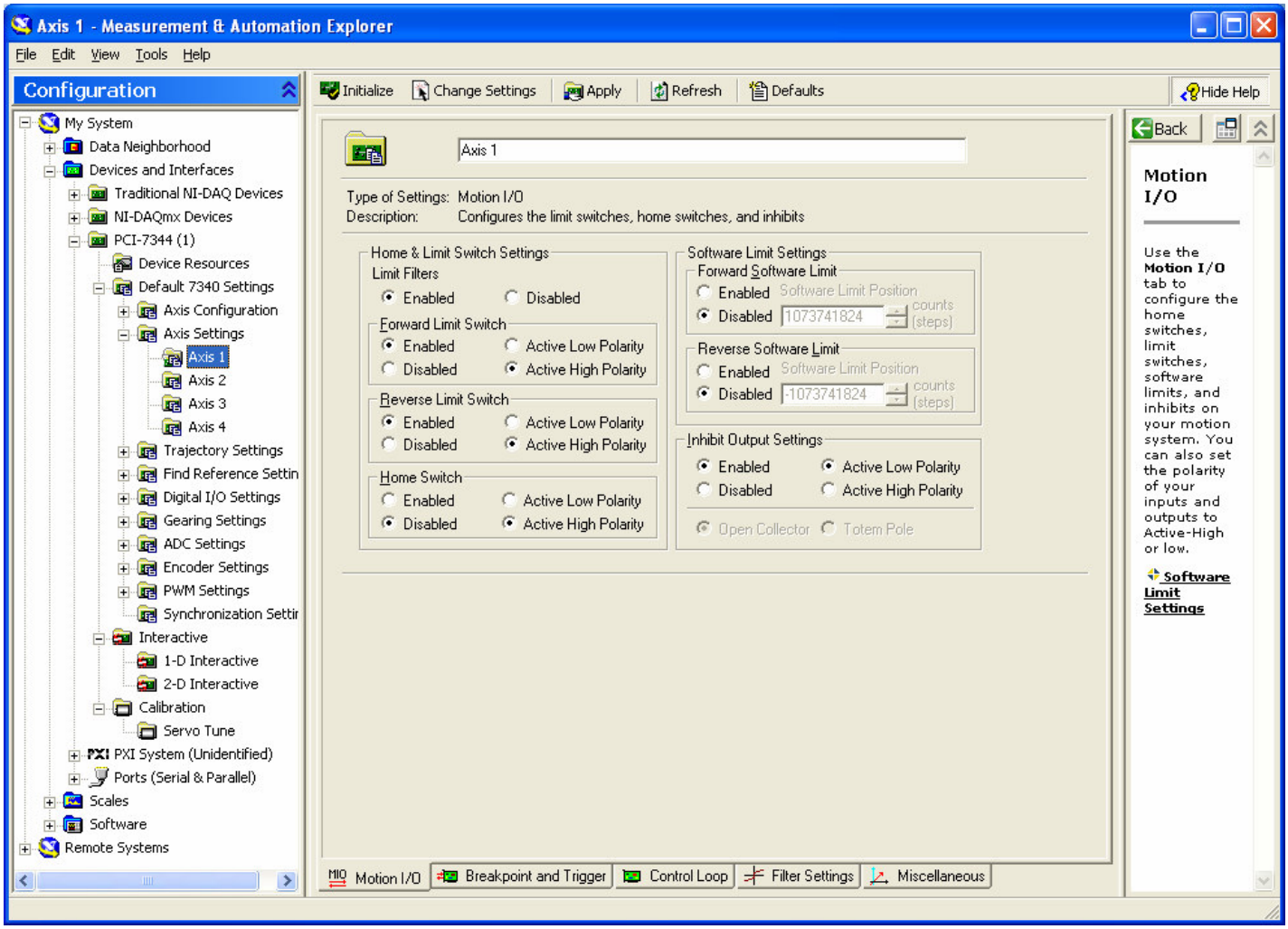

Figure 2. Axis settings for limit and home switch logic. Note the tabs at the bottom of this pane—we will be using these to adjust the PID gains.

Example PID Gains: M-126.CG

The M-126.CG rotation stage offers a DC servo motor with a worm-gear drive. A motor-mounted encoder provides position feedback.

We found the aggressive settings shown in Figure 3 to provide the fastest settling, although with some overshoot (Figure 4). You may wish to reduce the Proportional and Integral gains for your application, particularly if your load has a substantial moment of inertia. Some optimization for each application is expected.

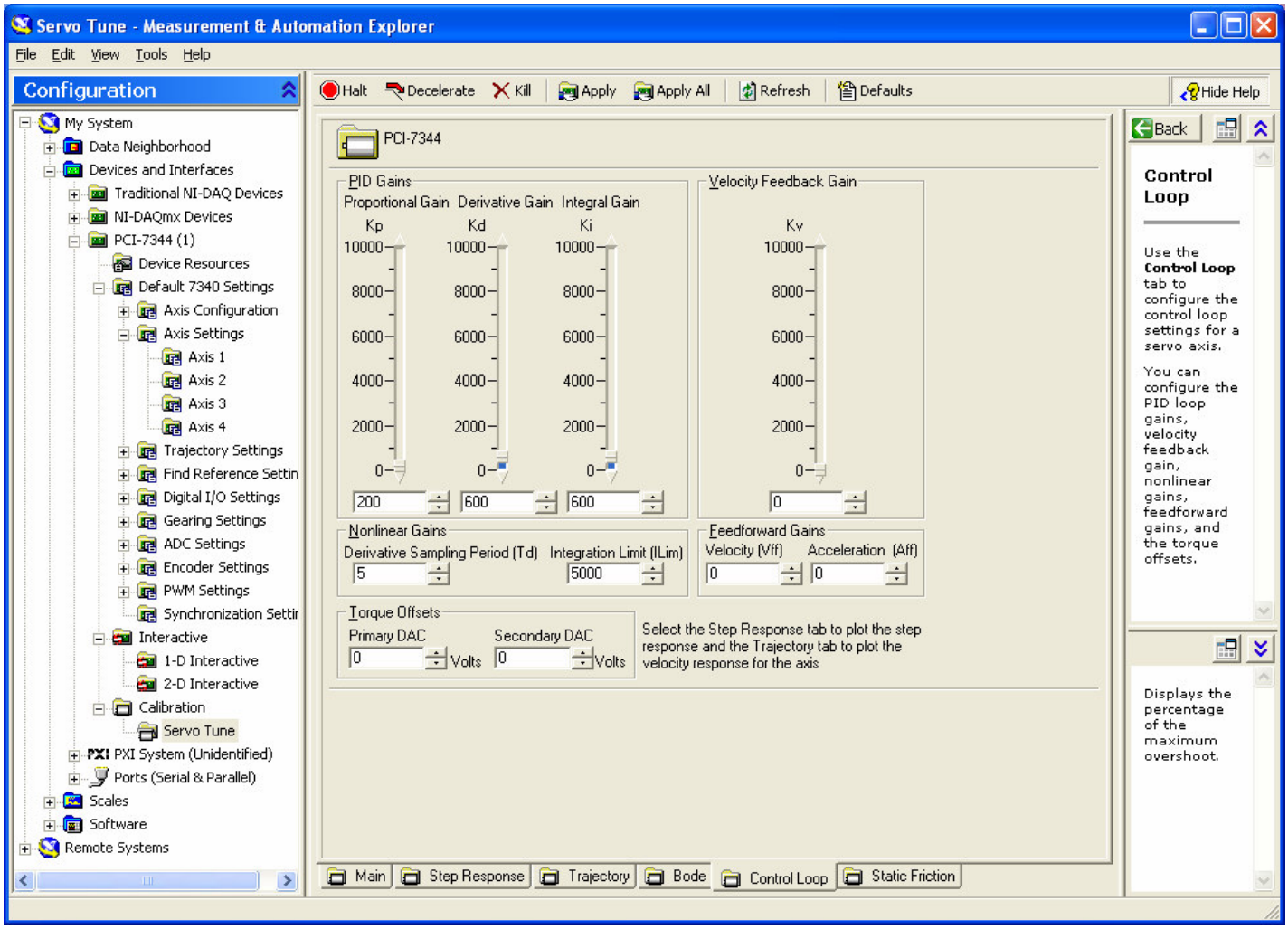

Figure 3. PID settings for M-126.PD

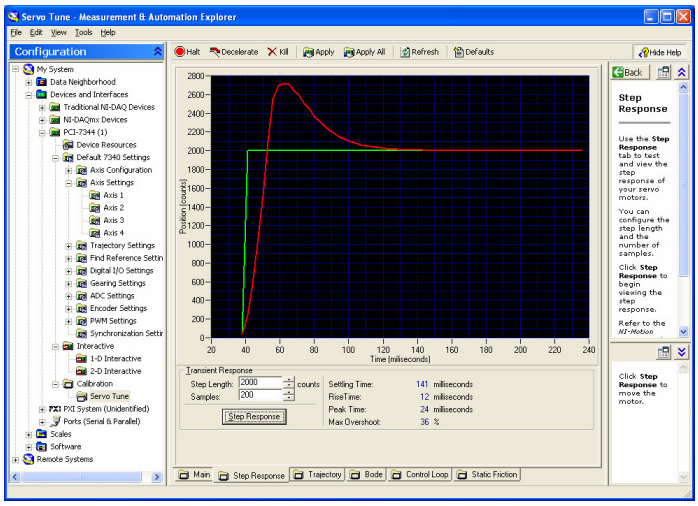

Figure 4. The settings documented for this stage in Figure 3 result in fast settling, though with some overshoot, as visualized with the Servo Tune pane in the Calibration heading of the NI controller in NI-MAX.

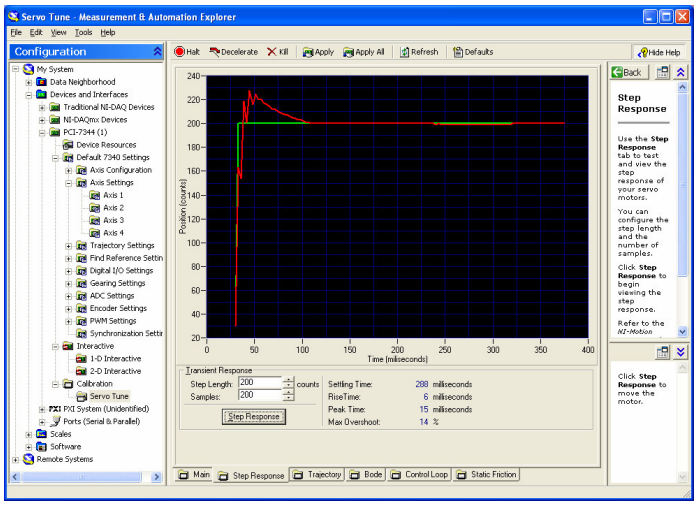

Figure 5. Small-step tests also show quick pull-in and in-position stability with the settings from Figure 3.

Note that if you are familiar with PI's digital piezo servocontrollers, the function of the Integral term is different. In NI's controllers, increasing the Integral gain parameter increases the gain directly. In PI's digital controller implementations, the integrator parameter is a time constant, so increasing it softens the servo—the opposite behavior.

Table 1 summarizes similar settings for a variety of PI motion devices.

Stage	Kp	Kd	Ki	Td	Ilim
M-126.CG	200	600	600	5	5000
M-126.PD	400	600	600	5	5000
M-405.PD	220	800	500	5	5000
M-126.DD	50	200	90	5	100
M-521.DDB (linear scale)	20	250	250	1	10

Table 1. PID settings for various PI stages when used with NI controller at 250µsec update rate.