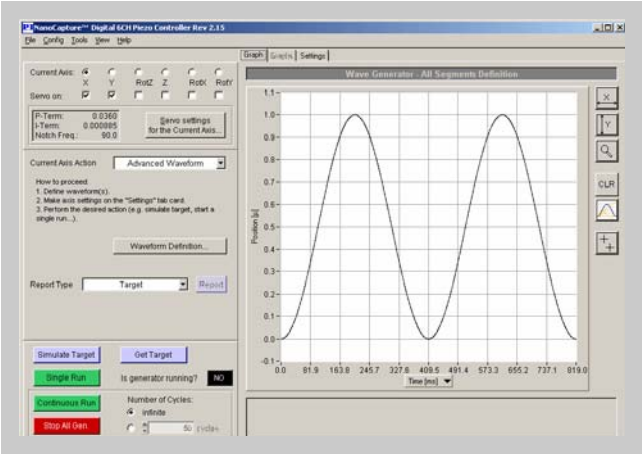
Piezo · Nano · Positioning

SM 71E Software Manual

NanoCapture™

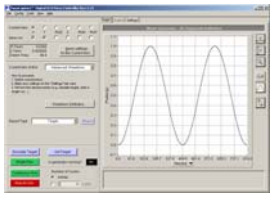
Release: 4.2.0 Date: 2006-12-16

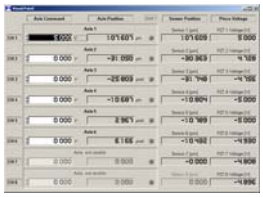


This document describes software for use with the following product(s):

- E-710 (3- and 4-Channel Versions)
  Digital Piezo Controller with firmware version greater than or equal to 5.27 / 6.27 and 7.xxx, but not from 6.00 through 6.26
- E-710 (6-Channel Version)
  6-Channel Digital Piezo Controller with firmware 2.12 or newer
- E-761.3CD
  3-Channel Digital Piezo Controller PCI Board
- E-755
  Single-Axis Digital Controller for NEXLINE® Linear Drives, open-loop models (E-755.101) and closed-loop models (E-755.1A1)

See accompanying Technical Note if using *NanoCapture*™ with other hardware.





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File:NanoCapture_SM071E.doc, 868352 Bytes

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0.3. Availability of Program and Documentation

NanoCapture™ and this document, as well as the other software tools and manuals for the accompanying Digital Piezo Controller can be found in machine-readable form on the product CD. Updated releases are available for download at www.pi.ws or via email: contact your Physik Instrumente sales engineer or write info@pi.ws.

1. Introduction

NanoCapture™ greatly facilitates use and performance optimization of the E-7XX Digital Controller series. In addition to standard functions for operation of nanopositioning systems, *NanoCapture*™ features advanced measurement and analysis functions, such as resonant frequency determination, overshoot, step-and-settle analysis, Bode plots, etc. These features are especially useful when the mechanical properties of a (factory-) calibrated system are changed at the operational site, such as by increased or reduced loading, different orientation or different damping conditions.

When this occurs, servo-control parameters such as gain, notch-filter frequency, etc. need to be adjusted to maintain optimum system response and stability. *NanoCapture*™ supports the operator, providing system resonant frequency, rise and settling time by analyzing the dynamic position feedback data from the nanopositioning system's sensor (no other metrology or instrumentation is required!). Based on this data, servo-control parameters can be easily adjusted for optimized settling.

NanoCapture™ allows setting the position sensor's zero position for a perfect match of the piezo controller's electrical range and the nanopositioning system's mechanical range.

If the controller is equipped with wave generator functionality, *NanoCapture*™ provides the opportunity to create wave forms and to experiment with them, including measurement and analysis functions.

Note that the availability of some features depends on the controller used—see Section 11 on p. 56 for an overview.

Settings can be stored to the non-volatile memory of the controller or to parameter files on the host PC. Easy restoration of original settings after shipping is also possible because PI records data files of every E-7XX controller calibrated at the factory.

Since *NanoCapture*™ supports the PI General Command Set and uses the GCS DLL, it offers an easy way to try out and observe the functions in this DLL before writing a custom application.

Warning: Most piezo actuators that can be connected to the controllers can be destroyed by *uncontrolled* oscillation near the mechanical resonant frequency. If you observe resonance while configuring your system, switch off power to the actuators concerned immediately and check the settings and servo-control parameters.

2. Software Installation

2.1. Installation

The software package installs with the familiar installation procedure: a setup program guides you through all installation steps using interactive dialogs. This program is located in the root directory of the product CD. After running the program, *NanoCapture*™ is fully installed.

2.2. Deinstallation

During installation, *NanoCapture*™ registers itself in the Windows system. This enables automatic de-installation using the mechanism supported by the Windows operating system. When starting the item *Add/Remove Programs* or *Software* in the *Control Panel*, the pop-up dialog shows a software list with the *NanoCapture*™ entry. By selecting this item, *NanoCapture*™ can be completely removed.

Note

When you install *NanoCapture*™, the National Instruments CVI runtime engine is installed also.

3. Quick Start

3.1. First Steps

1. Make the system (controller(s), stage(s), host PC) ready for use as described in the controller User Manual (e.g. software / hardware installation, hardware connections, daisy chain (if supported), power-up).
2. Start the *NanoCapture*™ host software.
3. When *NanoCapture*™ is started for the first time, the *Device Connection* configuration dialog will be displayed (see Fig. 1).
   Thereafter, the software will initialize the connection automatically with the last-used settings. These settings can be changed using the *Config* → *Device Connection* menu sequence.
   If you do not want the connection to be initialized automatically at the next software start, uncheck the "Reconnect device automatically at next startup" checkbox.
4. Select the *PI Controller* to use. Depending on the controller chosen, the *PC Interface* selection is adapted from the program.
5. If several interfaces are available, select the *PC Interface* to use to communicate with the controller. The terms IEEE 488 and GPIB are used interchangeably.
6. Configure the interface:
   - RS-232 serial interface: Select the baud rate and the desired COM interface to use on the host computer. *NanoCapture*™ will automatically reset the controller baud rate to match.
     If daisy chain connections are supported by the selected controller and you want to use a device which is part of a daisy chain, activate the *Use Daisy Chain* checkbox.
   - IEEE 488: Enter the GPIB *Board ID* and the *Device Address* for the controller. The default address is given in the controller User Manual and is probably 4.
   - PCI bus: Enter the *Board ID* for the controller.

   See Section 3.2 for more information.
7. Press the *OK-Connect* button.
   - E-710: You will be asked which of the axes supported by the controller are to be made available for use (see Fig. 2). If you cancel the selection, the device will be automatically disconnected.

- E-755: If you have activated the *Use Daisy Chain* checkbox in Step 6, you have to select the device you want to work with from the *Select Device* dialog. You can select only one device at a time.

When the connection and the controller are successfully initialized, *NanoCapture™* starts to upload the current parameter settings from the controller. When the upload procedure is finished the available axes will appear in the main window and the *Device Connection* configuration window will close automatically.

8. For controllers which support incremental sensors (e.g. E-755.1A1): If some axes are not referenced while connecting the controller, you will be asked if you want to open the *Axes Referencing* window. See Section 5.3 on p. 20 for details.
9. If the connection is not successful, refer to the “Troubleshooting” section, p. 57.

3.2. Establishing Connection—Details

The *Device Connection* window (Fig. 1) is used to establish a connection. If it does not appear when you need it, it can be opened via the *Config* menu.

Depending on the controller used, the following additional dialogs may open up automatically during establishing a connection:

- The *Select the connected axis* window (Fig. 2) where the axes need to be configured if they are not automatically get from the controller. If you want to modify the configured axes, open the window with the *Config* → *Connected Axes Selection* menu sequence. See also Section 5.2 on p. 19.
- A dialog (Fig. 3) where you will be asked if you want to open the *Axes Referencing* window if some axes are not referenced while connecting the controller. See Section 5.3 on p. 20 for details.

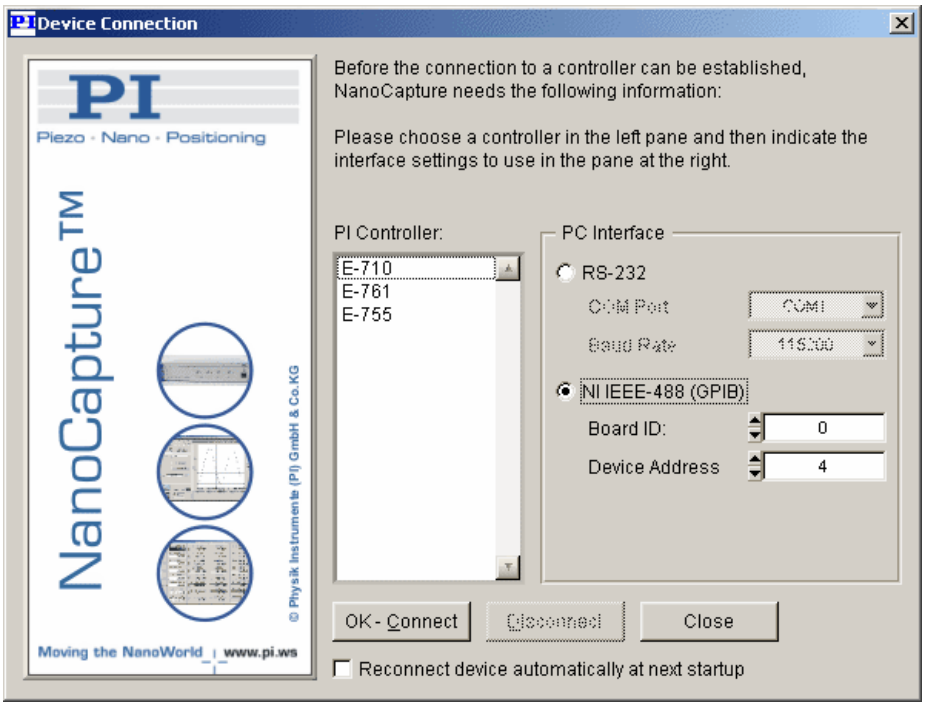


Fig. 1. Device Connection *window before connection*

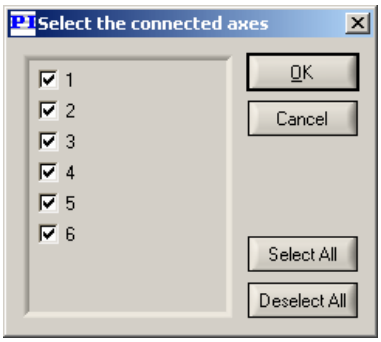


Fig. 2. Connected axis selection window

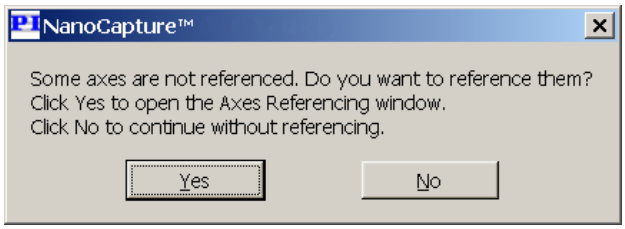


Fig. 3. Dialog for opening the Axis Referencing *window*

NanoCapture™ automatically adapts to the PC interfaces which are supported by the controller that is selected in the *PI Controller* field. See the User Manual of your controller for more information regarding the provided interfaces. Not all of the interfaces described below may be available for your controller.

3.2.1. RS-232 Settings

- **COM Port**: Select the desired COM port of the PC, something like “COM1” or ”COM2”. Only the ports available on the system will appear in the list.
- **Baud Rate**: The baud rate to use for the interface. No matter what baud rate the controller is set to, *NanoCapture*™ will establish initial contact and send the commands necessary to change the controller baud rate to the value specified.
- ***Use Daisy Chain* checkbox**: only present if daisy chain connections are supported by the selected controller. If you want to use a device which is part of a daisy chain, activate this checkbox. After you have pressed the *OK - Connect* button, you will have to select the device you want to work with (if more than 1 device is present). In the appropriate *Select Device* dialog, you can select only one device at a time.

Notes

See the controllers User Manual for more information regarding daisy chain connections.

If you want to use a daisy chain connection, interconnect all devices before you power them up.

In the *Command Terminal* of *NanoCapture*™ always use the "normal" syntax and not the special syntax with TargetID and SenderID which is described in the controllers User Manual. The GCS DLL used by *NanoCapture*™ internally handles the TargetIDs and SenderIDs.

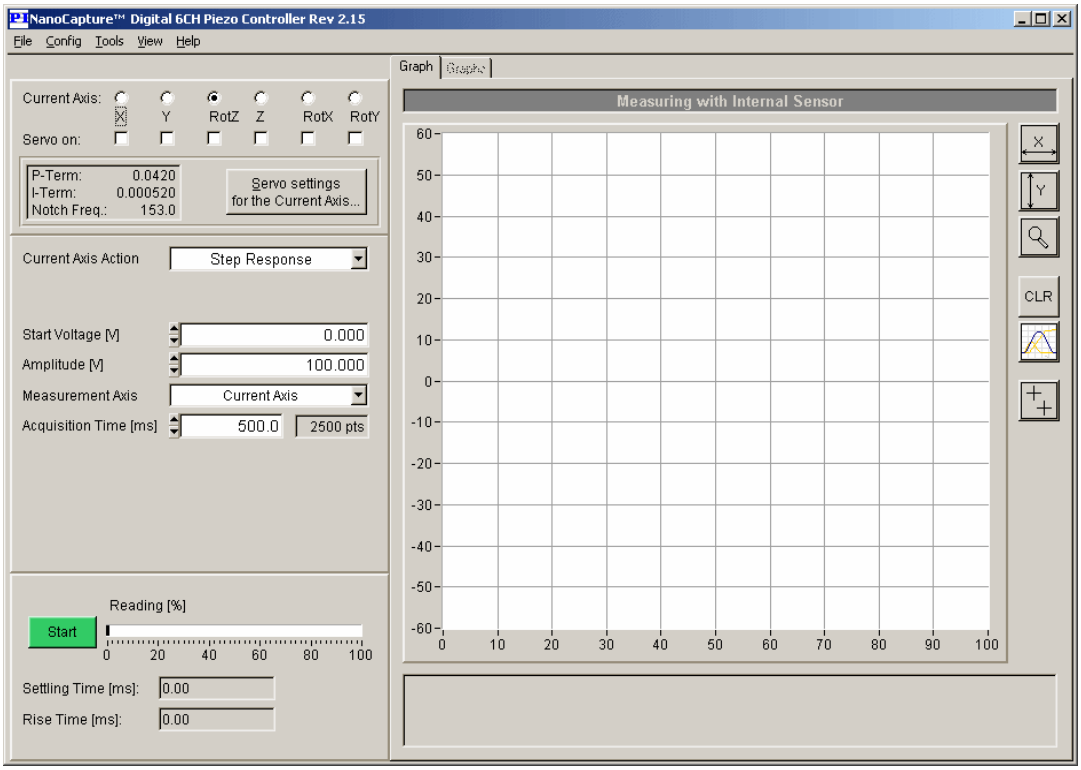
3.2.2. IEEE 488 (GPIB) Settings

- **Board ID:** ID of the National Instruments board installed. If, as in the usual case, only one board is installed, this will be 0. Otherwise, use the National Instruments setup and test software to determine the board ID.
- **GPIB Address:** This is the address of the connected device, not the number of the board in the host computer. Please read the documentation of your controller to determine its address setting. It is probably 4.

3.2.3. PCI Board Settings

- **Board ID:** ID of the E-7XX PCI board installed. If, as in the usual case, only one board is installed, this will be 1.

4. Main Window



The *NanoCapture*™ main window consists of:

- Menu bar
- Current axis field, with:
  - Radio buttons to select the logical axis to be considered the “current” axis by many *NanoCapture*™ controls. The axes are arranged in numerical order starting with axis 1 at the left.
  - Checkboxes to set the servo mode of each axis
  - A display field showing the main servo parameters for the current axis or the reference state of the current axis.
  - A command button to open either the *Dynamic tuner* window where the current axis’ main servo parameters (and some others) can be changed or the *Axes Referencing* window where a reference motion can be started for the current axis
- Action field with:
  - A selection control to select the action to perform. The selected action will be applied to the current axis, except when *Advanced Waveform* or *Record Table Report* is chosen. The controls displayed below this field change depending on the action selected and in some cases depending on the current servo state.
  - Controls to configure the selected action.
  - Button to start the action.
  - Value indicators.
- Graphic Report / Settings field with tab cards—not all cards are always available, the availability depends on the controller used and on the action selected in the Action field:
  - *Graph* and *Graphs* cards contain:

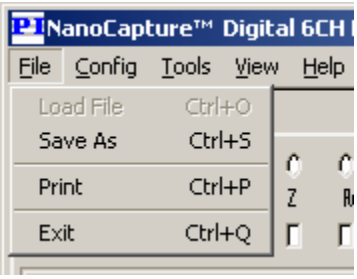
- Title with information about what is currently displayed on the graph(s)
- Graph(s) for the reports
- Graph controls: e.g. buttons to control the graph scales and to set some graph properties
- Absolute and relative position indicators for the two cross-hair cursors, which can be activated by the corresponding graph controls and placed on the graph.

o *Settings* card contains settings for the advanced waveforms.

o *Record Tables* card contains settings for the record tables and triggers.

4.1. Menu Bar

4.1.1. File Menu



- *Load File* permits loading a measurement data file (the results of a step or frequency response, or a record table report) and displays both the measurement configuration and the measured curve in the main window. This menu item is only enabled when no device is connected to the *NanoCapture*™ software.
- *Save As* permits saving the currently displayed measurement curve and the corresponding measurement configuration. *Step Response, Frequency Response* results and *Record Table Reports* can be saved that way.
- *Print* permits printing the current main window. With some printer setups it may be necessary to activate “Force black & white” in the printer dialog, especially if curves in orange are displayed.
- *Exit* permits quitting the *NanoCapture*™ software.

4.1.2. Config Menu

The appearance of the *Config* menu depends on the controller used. Not all items are always available.

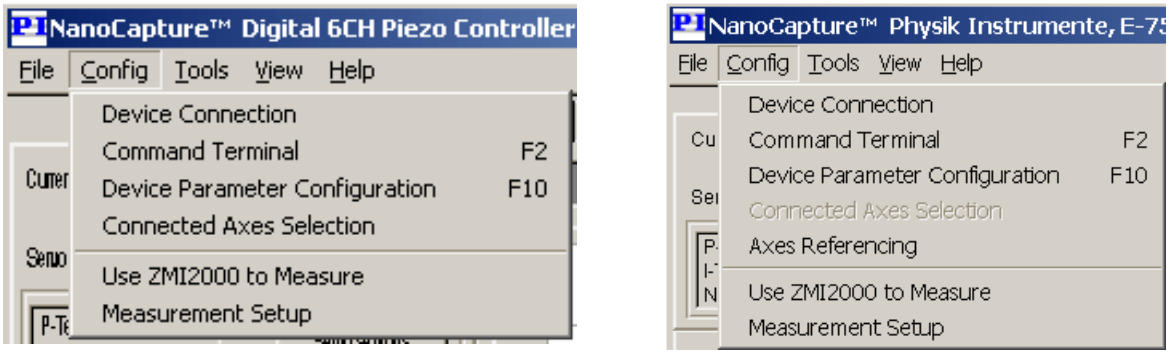
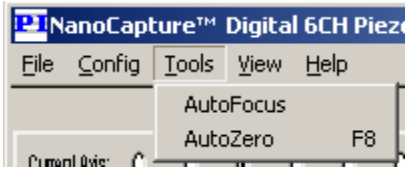


Fig. 4. Config *menus for different controllers (left: E-710, right: E-755.1A1 closed-loop device)*

- *Device Connection* opens the *Device Connection* window to manage communication with the controller (connect/disconnect; see Section 3.2).
- *Command Terminal* permits accessing the *Command Terminal* window to enter ASCII commands (see Section 5.1).
- *Device Parameter Configuration* permits accessing the *Device Parameter Configuration* window for controller parameter management (see Section 9).
- *Connected Axes Selection* permits redefining which of the axes supported by the controller are to be made available for use (see Section 5.2).
- *Axes Referencing* permits accessing the *Axes Referencing* window to see the reference state of each axis and to start referencing them (see Section 5.3).
- *Use ZMI2000 to Measure* permits configuring and using the ZMI2000 Interferometer as a measuring device (PI use only).
- *Measurement Setup* permits defining the meanings of settling time and rise time, the number of decimal places for some elements on the user interface, and some controller specific parameters (see Section 5.4).

4.1.3. Tools Menu

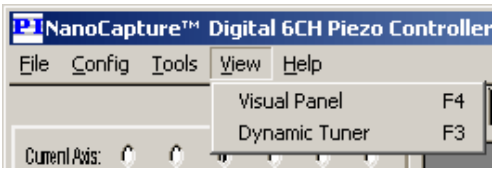
The appearance of the *Tools* menu depends on the controller used. Not all items are always available.



- *AutoFocus* permits accessing the *AutoFocus* window to configure and start auto focusing the current axis (see Section 5.5).
- *AutoZero* permits accessing the *AutoZero* window to perform the automatic zero point calibration of the mechanics (see Section 5.6).

4.1.4. View Menu

The appearance of the *View* menu depends on the controller used. Not all items are always available.



- *Visual Panel* pops up the *Visual Panel* window, which permits commanding each axis and displays the axis positions, the sensor values and the piezo voltages (see Section 5.7).
- *Dynamic Tuner* pops up the extended servo parameters window (see Section 7.2).

4.1.5. Help Menu

- *Device Info* pops up a window displaying the identification string from the controller
- *About* pops up a window containing information about the *NanoCapture*™ software, including its version number.

4.2. Current-Axis Pane

The appearance of the *Current-Axis* pane depends on the controller used and on the current axis state. Not all items are always available.

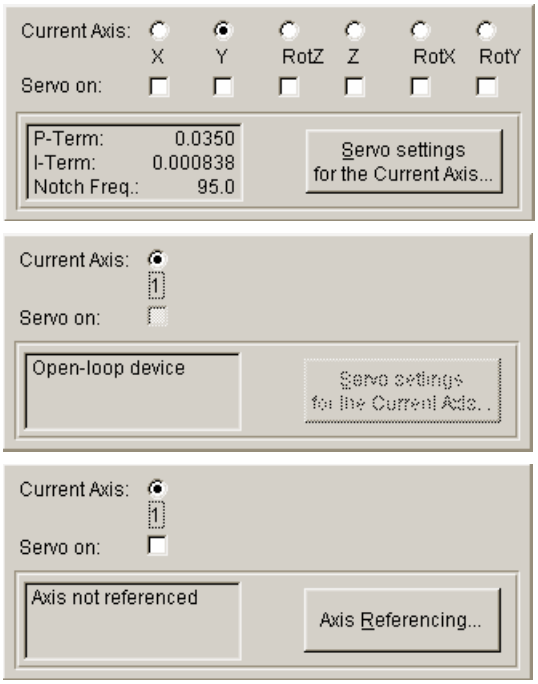


Fig. 5. Current-Axis *panes for different controllers, top down: E-710 6-axis device, E-755.101 open-loop device, E-755.1A1 closed-loop device with unreferenced axis*

The radio buttons permit selection of the *Current Axis*, that is to say, the axis that will be used by default for certain actions and measurements that *NanoCapture*™ performs. All axes supported by the controller will have a radio button shown. Up to 6 axes can be supported, depending on the controller used.

Under each axis' radio button is a check box that can be used to turn that axis' servo-loop on or off. The check box is dimmed for open-loop devices or when the servo of the axis is disabled (parameter ID 0x07000801).

When an axis is not configured (see Section 5.2 on p. 19) or when at least one of the sensors used by the axis is disabled, the radio button and the servo-loop check box of this axis are dimmed.

Below the radio buttons and servo check boxes, there are a display field and a button whose appearance differs depending on the controller used and on the current axis state:

- The display field shows one of the following options:
  - The main servo parameters (P-Term, I-Term and Notch Frequency) for the current axis
  - The referencing state for the current axis (see Section 5.3)
  - "Open-loop device" for controllers which are not equipped with sensor processing electronics (currently E-755.101)
- The button can have the following functions:
  - When labelled with *Servo settings for the Current Axis…*, the button opens the *Dynamic Tuner* window where the current axis servo and filter parameters can be edited and saved (see Section 7).
  - When labelled with *Axis Referencing…*, the button opens the *Axes Referencing* window where a reference motion can be started for the current axis (see Section 5.3).

4.3. Action Pane

The appearance of the *Action* pane depends on the controller used and on the servo state of the current axis. Not all items are always available.

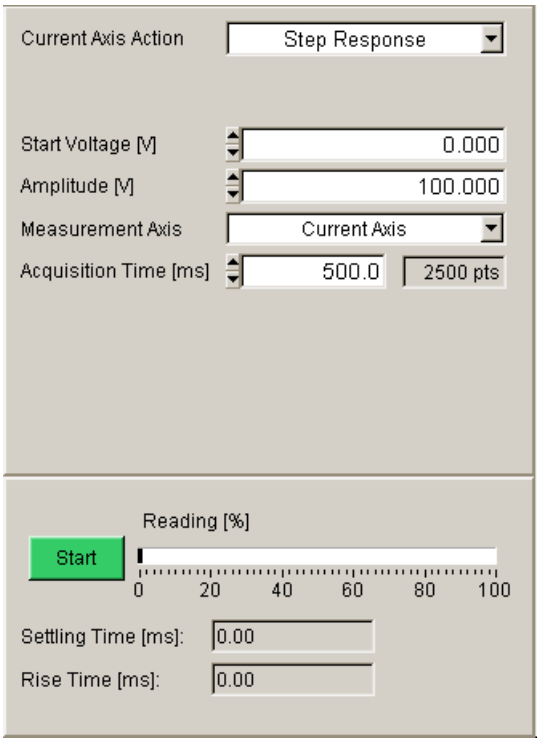


Fig. 6.

The *Current Axis Action* selection control permits choosing the action to configure, perform and measure. Following actions may be available, depending on the controller used:

- *Step Response*
- *Frequency Response*
- *Simple Waveform*
- *Advanced Waveform*
- *Record Table Report*

The action pane layout changes depending on the action selected in the *Current Axis Action* control and sometimes also depending on the current servo state of the axis. You will find more information about the actions and their configuration in Section 6 for *Step* and *Frequency Response,* in Section 8 for *Simple* and *Advanced Waveform* and in Section 9 for *Record Table Report*.

4.4. Graphic Report / Settings Field with Tab Cards

The appearance of the *Graphic Report / Settings* field depends on the controller used. Not all tab cards are always available.

This section describes only the *Graph* and *Graphs* tab cards, while the *Settings* and *Record Table Report* tab cards are described in separate sections:

→ *Settings* tab card: see Section 8.2.3 on p. 43; is only available when "Advanced Waveform" is selected for *Current Axis Action*

→ *Record Table Report* tab card: see Section 9 on p. 46; is only available when "Record Table Report" is selected for *Current Axis Action*

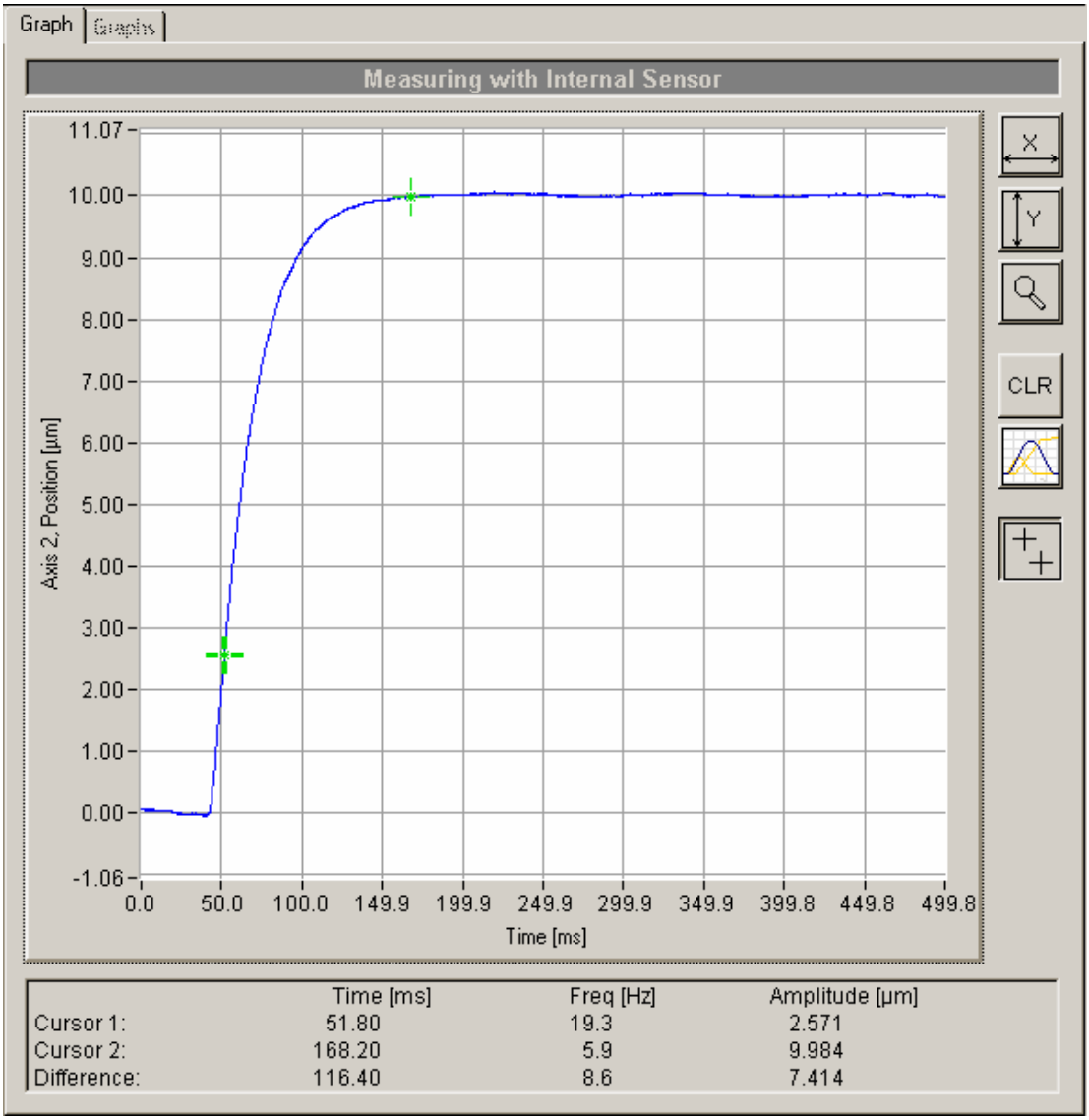


Fig. 7. Graph tab card

The main elements on the *Graph* and *Graphs* tab cards described here are the graphs. Depending on the controller used, the graphs can report the following:

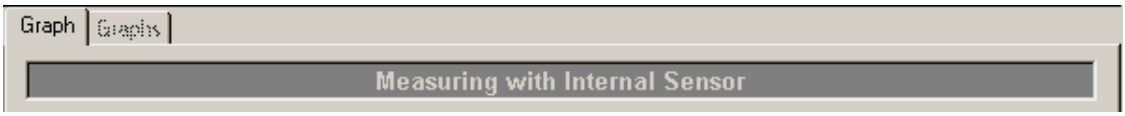
- Measurement results:
  The data displayed mainly result from actions that are performed directly in the *Action* pane (see Sections 6 and 8). Results from some actions done in the *Command Terminal* are available when *Record Table Report* is selected for *Current Axis Action* (see Sections 9 and 5.1).
- Preview of defined segments for the wave generators.

- Wave Generator simulations

On the *Graph*, tab card a single large graph is presented.

On the *Graphs* tab card, three smaller graphs are displayed (see Fig. 35, p. 45). They show the motion of each axis against time, and the positions of the axes plotted against each other. The *Graphs* tab card is available when at least two wave generators are used simultaneously.

Above the graph is a title line to clarify what is displayed (see below). For the same reason, the vertical and horizontal axes are automatically graduated and labelled.



After each curve display, the graph(s) autoscale(s) around all displayed curves.

The graph control bar to the right of the graph permits controlling the graph display.

The three first buttons relate to the scales; they permit:

- Autoscaling the horizontal (X) axis or axes.
- Autoscaling the vertical (Y) axis or axes.
- Enabling/disabling the zoom option on the graph.

If the zoom option is enabled:

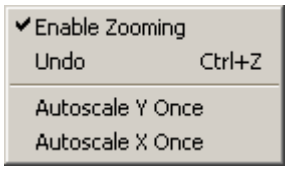
- You can zoom in on the graph by holding the left mouse button depressed and dragging the pointer diagonally across a rectangular area. When you release the button, the rectangle will be zoomed to fill the graph.
- You can enter the scale ranges for the graph display manually in the controls that appear below the graph.

Ctrl-Z undoes the zoom.

Note

Enabling the zoom option when the cross-hair cursors are enabled will disable the cursors.

These actions are also on the graph's context menu (right-click on the graph) The check mark next to *Enable Zooming* in the example indicates that the zoom option is enabled.



The two next buttons relate to the content of the graph(s); they permit:

- Clearing the graph(s).
- Keeping old curves on the graph(s).

The color used for old curves is orange.

Note that the different curves displayed are positioned numerically, but the meaning and units of the older curves

may not correspond to the axis labels.

The last button permits enabling/disabling the use of two cross-hair cursors on the graph.

Note

Enabling cursor use when the zoom option is enabled will disable the zoom option.

When the cursors are enabled, the cursor measurement indicator under the graph displays cursor information. The kind of information displayed depends on the graphs.

4.4.1. Using the Cross-Hair Cursors

Enable cursor use with the graph control button just as described above to make two cross-hair cursors available for placement on the graph.

The cursors can be moved along the most recent measurement curve(s) with the mouse and also from point to point with the arrow keys. Holding Shift depressed while using the arrow keys permits moving a cursor with larger steps (10 points). When several curves were obtained on the last measurement run (only for the wave generator results, when choosing the *Target, Real, Error* positions to be reported), you hop from one curve to the other with the two-key combinations Shift–Page Up and Shift–Page Down.

The cursor information will be displayed in the indicator field under the graph, the information layout depending on what was measured.

5. Secondary Windows

5.1. Command Terminal

Config → Command Terminal

This window permits entering ASCII commands.

5.1.1. Command Set (only for E-710)

Radio buttons at the bottom of the window can be used to choose the desired command set. The default is the PI General Command Set (GCS), which is understood by most PI controllers.

- GCS: In the GCS DLL manual, the GCS command corresponding to each DLL function call is given, along with a description of its arguments and functionality. The HLP? command can also be used to obtain a list of the valid commands. Note that:
  - To omit a GCS argument, you must replace it with the string “nan”
  - Some GCS commands require command level 1. The password required with the CCL 1 command is “advanced”.
- Native: commands entered must be from the command set described in User Manual and/or any Technical Note for the controller. The HE command gives a list of available commands (it may be necessary to press Enter several times to clear the buffer).

Switching back and forth between command sets is not recommended. The GCS software interface was written under the assumption that it would be aware of all commands the controller receives. Interspersing GCS and native commands

requires an in-depth knowledge of the controller operation and the GCS implementation and is almost certain to cause unexpected results.

Compound native commands which produce reports and include wait and/or repeat commands may cause irremediable timeouts.

5.1.2. Command Entry

See the User Manual of your controller for the available commands and their syntax.

Notes

Non-GCS firmware:

If the currently connected controller has a non-GCS firmware (e.g. E-710), it can be operated with two command sets: its native ASCII commands and the PI General Command Set. The native ASCII command set is understood by the firmware (see the controller's User Manual for more information). To enable the usage of the GCS commands, the GCS DLL translates GCS commands into the native commands (see the GCS DLL manual of the controller for more information). See Section 5.1.1 for how to select the desired command set.

Do not mix up the GCS command set and the native command set! GCS move commands do not work properly anymore after the position was changed by native commands.

Daisy chain:

Even if the currently connected controller is part of a daisy chain, always use the "normal" syntax and not the special daisy chain syntax with TargetID and SenderID which is described in the controllers User Manual. The GCS DLL used by *NanoCapture*™ internally handles the TargetIDs and SenderIDs.

- *Command Entry* field: ASCII commands from the selected command set can be entered and edited.
- *Execute Command* button or the Enter key executes the command.
  Note that when the *Command Entry* field is empty, the last command executed in the terminal will be executed again.
- *Abort Command* can be used to stop lengthy commands.
- *ERR?* button can be used as a shortcut for updating, interrogating and resetting the GCS-DLL error state. When using the GCS command set, this button is the same as entering and sending the ERR? command.
  E-710 only: When using the native command set, note that some command errors will not be signaled, and successful native commands may not clear the DLL error state.

A log of commands and responses with a vertical scroll bar is provided below the *Execute Command* button.

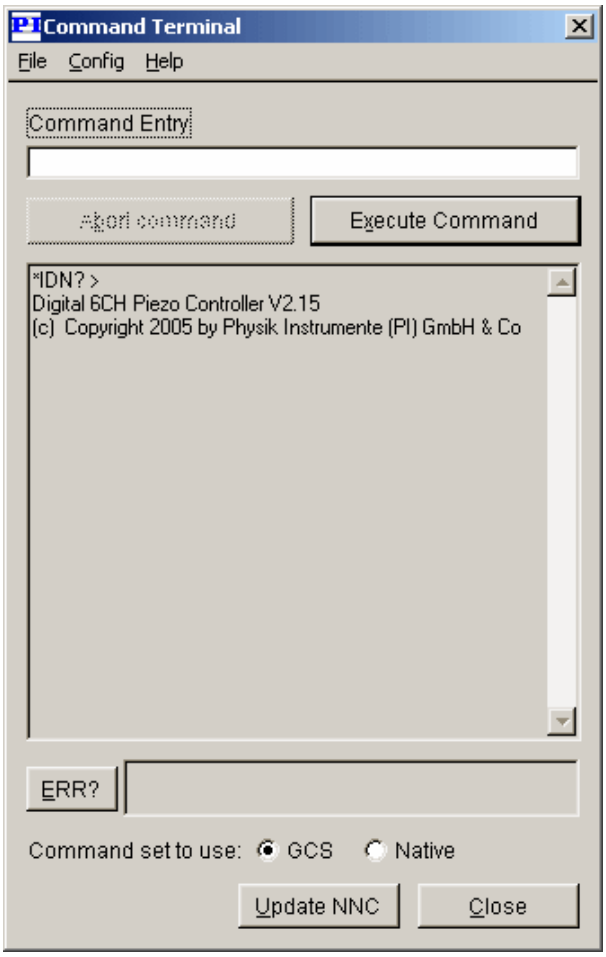


Fig. 8.Command Terminal window

Press the *Close* button to quit the *Command Terminal* window. If certain specific commands were sent, *NanoCapture*™ will start to upload the current parameters from the controller for use in the various *NanoCapture*™ windows (servo-loop state, axis names, etc). The same behaviour occurs when you quit the *Command Terminal* window with the standard close button .

You can also induce this behaviour (parameter upload and program update) at any time without quitting the *Command Terminal* window by pressing the *Update NNC* button (*NNC* stands here for *NanoCapture*™).

CAUTION

An asterisk on the *Update NNC* button indicates that the program needs to be updated to work correctly.

5.2. Select the Connected Axes

Depending on the controller used, the *Select the connected axis* window (Fig. 9) is available. It opens automatically when the communication to the controller is established and axes need to be configured, or the configured axes are automatically got from the controller. If you want to modify the configured axes, open the window with the *Config* → *Connected Axes Selection* menu sequence. When called from the menu, this window has the following behaviour (differs from the behaviour when it is opened automatically):

- The *OK* buttons accepts the new configuration and updates the *NanoCapture*™ software automatically.

- The *Cancel* button permits to keep the configuration as it was before calling this window from the menu.

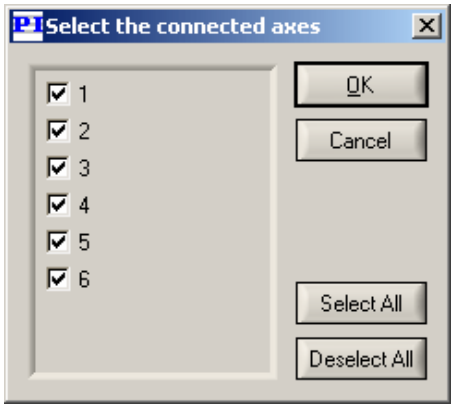


Fig. 9. Connected axis selection window

5.3. Axes Referencing

The availability of the axis referencing functionality depends on the controller used: some E-7XX controllers, e.g. E-755.1A1 closed-loop devices, are equipped with readout electronics for incremental sensors. Since incremental sensors can not acquire absolute positions, a referencing procedure is required before absolute target positions can be reached for an axis.

If some axes are not referenced while connecting the controller, you will be asked if you want to open the *Axes Referencing* window (see Fig. 10).

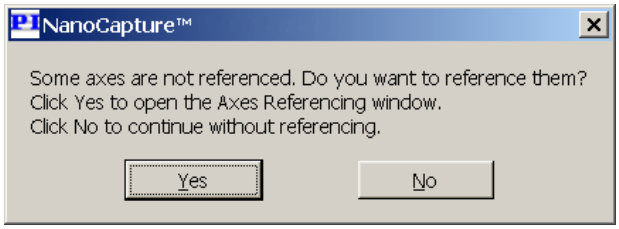


Fig. 10. Referencing dialog after controller connection

The *Axes Referencing* window can also be opened in the following ways:

- Using the *Config* → *Axes Referencing* menu sequence.
- Using the *Axis Referencing…* button in the *Current Axis* pane of the main window (see Fig. 11).
  The *Axis Referencing…* button and the referencing state display to the left of the button only appear when *NanoCapture*™ has detected that the current axis is not referenced. The referencing state display indicates—if detectable by the program—that the current axis is not referenced or that it is performing a reference move. When referencing was successfully done, the display shows the servo parameters again and the button is replaced with the *Servo settings for the Current Axis…* button.

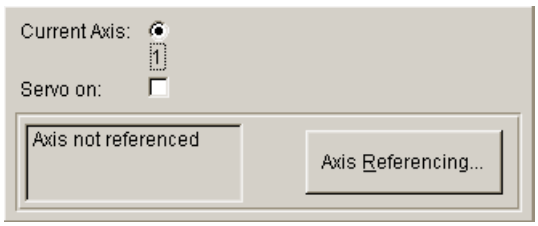


Fig. 11. Referencing display and button in the main window

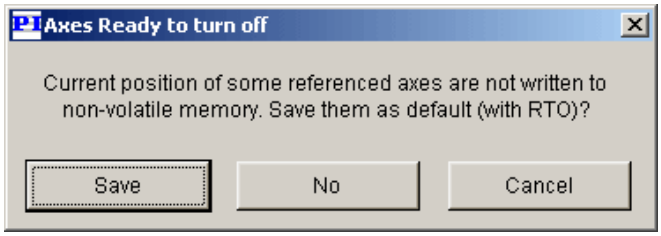
The *Axes Referencing* window (Fig. 12) permits commanding each axis separately to move to the negative or positive limit, or to its reference—if available. A status field permits to recognize if the axis is referenced or not, and also if it is referencing (provided that *NanoCapture*™ can detect it).

If the state is not correctly updated, you can press the *Update* button to get the axes state (referenced or not) from the controller.

The *Stop All Motions* button abruptly stops all motions and permits therefore interrupting the referencing operation.

Fig. 12. Axes Referencing *window*

It is possible to save the current position of referenced axes to the non-volatile memory of the controller (RTO command, see the controllers User Manual). If you save the current position immediately before shutting down the system, this position will be read back from non-volatile memory and set as current position when the controller is switched on the next time, and no new referencing procedure will be required. When *NanoCapture*™ is exited and some axes are referenced but their positions were not saved yet, you will therefore be asked about saving the positions as defaults in the controller:



5.4. Measurement Setup

Config → Measurement Setup

The settings in the *Measurement Setup* window affect several controller operations, e.g. the width of an impulse move and the duration of the measurement/recording, but also the operation of the wave generator. The settings will only become active when you press the *OK* button.

In the first two panes, you can specify the definitions to use for calculation of settling time and rise time to be used for a step response measurement.

In the third pane, you can specify the number of decimal places which will be used on the user interface for position and voltage command controls or for reading information (controls, cursor text).

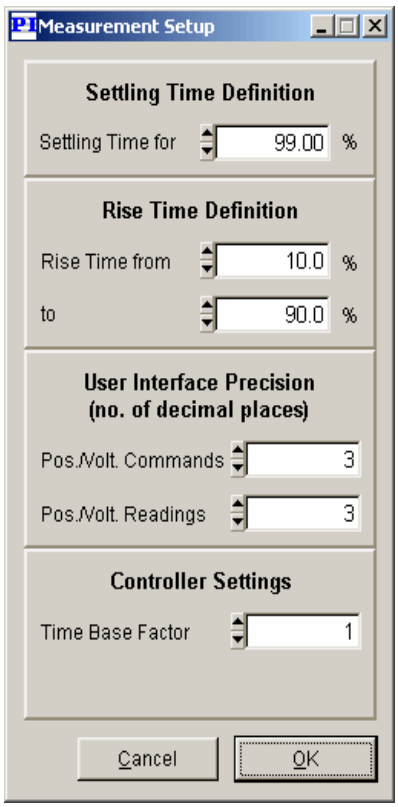


Fig. 13. Measurement Setup *window for E-710*

The content of the forth pane depends on the controller used:

- E-710: The *Time Base Factor* field can be used to set the “Table Rate” parameter, which affects the width of an impulse move, the delay between recorded data points, and operation of the Wave Generator (see also the SPA GCS command (with parameter 0x13000109) and the TR native command).
- E-761: The *Record Table Rate* field can be used to set the "Record Table Rate” parameter, which affects the delay between recorded data points. The *Oversampling (AVG)* field can be used to set the oversampling factor which affects the servo update time and hence the width of an impulse move and the duration of the measurement/recording, but also the operation of the wave generator. See also the AVG, RTR and SPA command descriptions in the E-761 User Manual. Note that the larger the values for *Record Table Rate* and *Oversampling* the longer the waiting time before measurement results will appear on the *Graph* and *Graphs* tab cards.
- E-755: The *Record Table Rate* field can be used to set the "Data Recorder Table Rate” parameter, which affects the delay between recorded data points (parameter ID 0x16000000). For parameter handling descriptions see the E-755 User Manual.

5.5. AutoFocus

Tools → AutoFocus

The availability of the AutoFocus functionality depends on the controller used.

This window permits

- Setting the necessary parameters to perform an AutoFocus operation.
- Saving these parameters as default in the controller EEPROM with the *Save as Default (EEPROM)* button.
- Executing the AutoFocus command from the controller with the *Start* button. The start position and the AutoFocus amplitude are taken from the *NanoCapture*™ main window (make sure *current axis* has servo ON).

See the controller User Manual or Technical Note for more information about the AutoFocus function and its parameters.

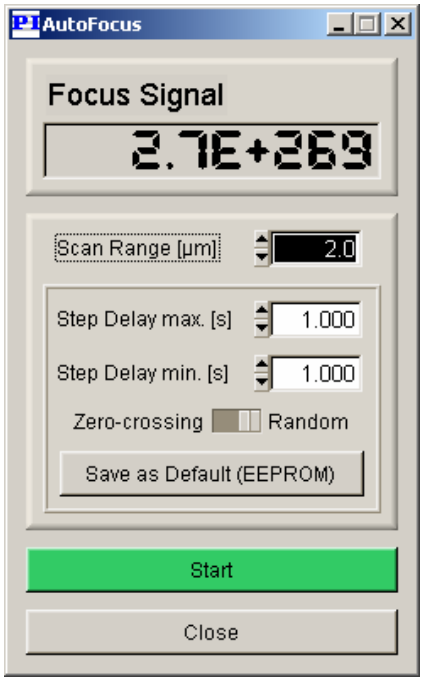


Fig. 14.

5.6. AutoZero

Tools → AutoZero

The availability of the AutoZero functionality depends on the controller used.

Both the range of axis position values (from the sensors, after coordinate transformation) and the range of axis motion control signals are limited. If there is an offset between the input and output ranges caused by a mechanical drift of the piezo actuator, then the usable range will be reduced. Such an offset can be compensated by the AutoZero function. For a more-detailed explanation of AutoZero, see the controller User Manual.

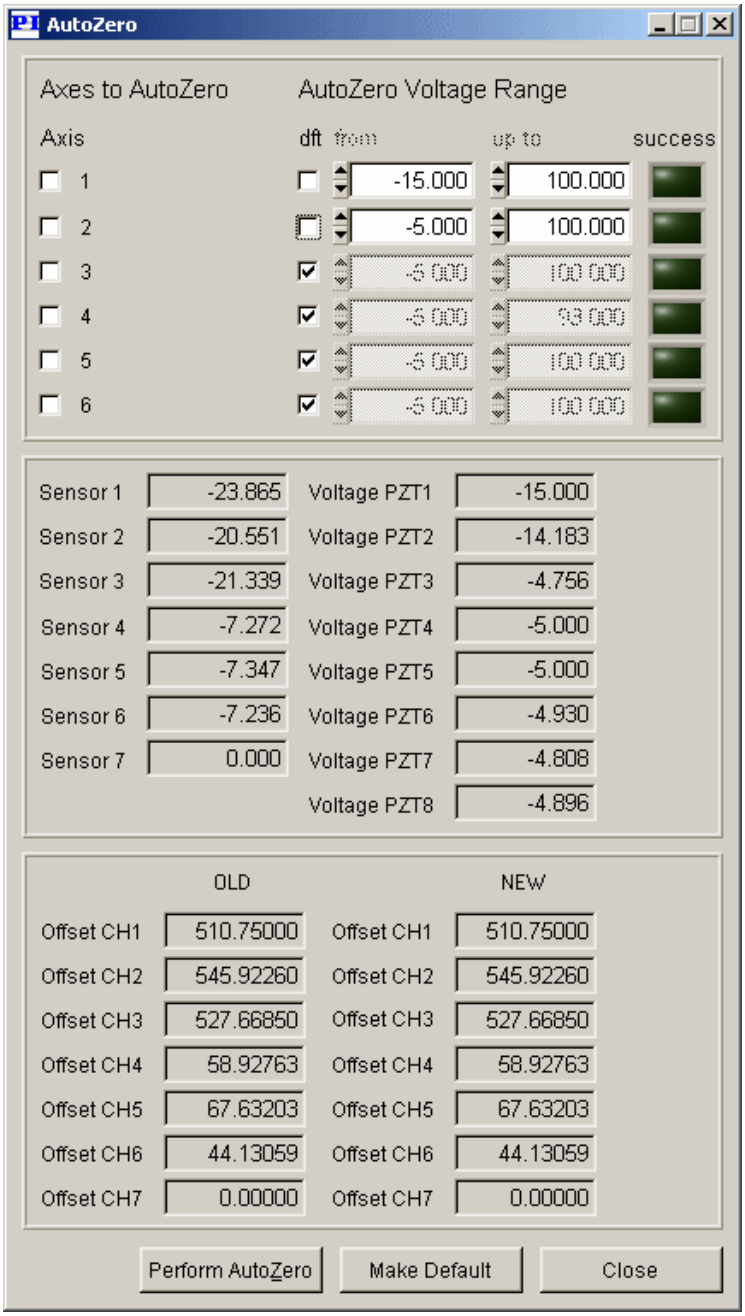


Fig. 15.

NanoCapture™ can usually recognize the axes and determine whether an axis is linear or rotational, and which PZTs and sensors have components in its direction.

AutoZero is used only on linear axes. If a rotational axis is suspected, *NanoCapture*™ displays a warning message.

5.6.1. When Should AutoZero Be Executed?

- If the stage and controller are not well known, executing AutoZero is the best way to begin.
- When the stage is first integrated into the application environment, AutoZero must be run.
- If only relative movement is important, executing AutoZero after every power up is recommended.

If absolute moves are needed, AutoZero should **not** be executed during normal operation because AutoZero changes the mechanical zero position of the piezo stage. AutoZero should be executed only when the stage is initially integrated into the application environment.

AutoZero is also recommended if the system is subjected to temperature changes.

5.6.2. AutoZero Procedure Details

Note that when multiple axes were selected using the *Axes to AutoZero* checkboxes, the individual axes will run through the procedure one after the other.

1. All affected axes are moved to target position 0.
2. All affected axes are set to voltage-control mode (servo OFF).

Then the following steps are run through once for each affected linear axis (for non-linear axes, the sensors will be zeroed at zero voltage without that axis having been driven forward and backward):

3. All PZTs having a component in the selected-axis direction are driven slowly to the zero voltage.
4. All PZTs having a component in the selected-axis direction are moved slowly to the position corresponding to the axis lower voltage (taken from the internally saved parameter for the voltage at the zero position if the *dft* (default) checkbox is marked, else taken from the voltage range specified in the AutoZero window).
5. All PZTs having a component in the selected-axis direction are moved slowly to the position corresponding to the axis upper voltage (taken from the internally saved parameter for the voltage at the zero position if the *dft* (default) checkbox is marked, else taken from the voltage range specified in the AutoZero window).
6. Now the operating voltage is decreased stepwise until the value corresponding to lower voltage is reached again.
7. Wait one second.
8. All sensor channels with components in the selected-axis direction get a new offset value, so that they show a value of zero.
9. Servo-control is switched back to its original state.

When lighting up, the green *success* LEDs in the *AutoZero* window indicate that the procedure was successfully executed for the corresponding axes.

You can save the voltage range for the selected axes and the corresponding new sensor offset (obtained during step 8 of the AutoZero procedure) by pressing the *Make Default* button to non-volatile memory as the new default value.

5.7. Visual Panel Window

View → Visual Panel

This window can also be opened by double-clicking in the current axis pane in the main window. The appearance of the *Visual Panel* depends on the controller used and on the current servo-loop state of the axes.

Use the *Visual Panel* window to see all axis and sensor channel positions, as well as all PZT channel voltages and the overflow state for the axes (if supported by the controller and if the corresponding axis is in closed-loop). Using the "command" fields in the first column of the *Visual Panel*, you can command the position or voltage (depending on the axis servo-mode) of each axis, while the resulting position and/or voltage values are shown in the subsequent columns.

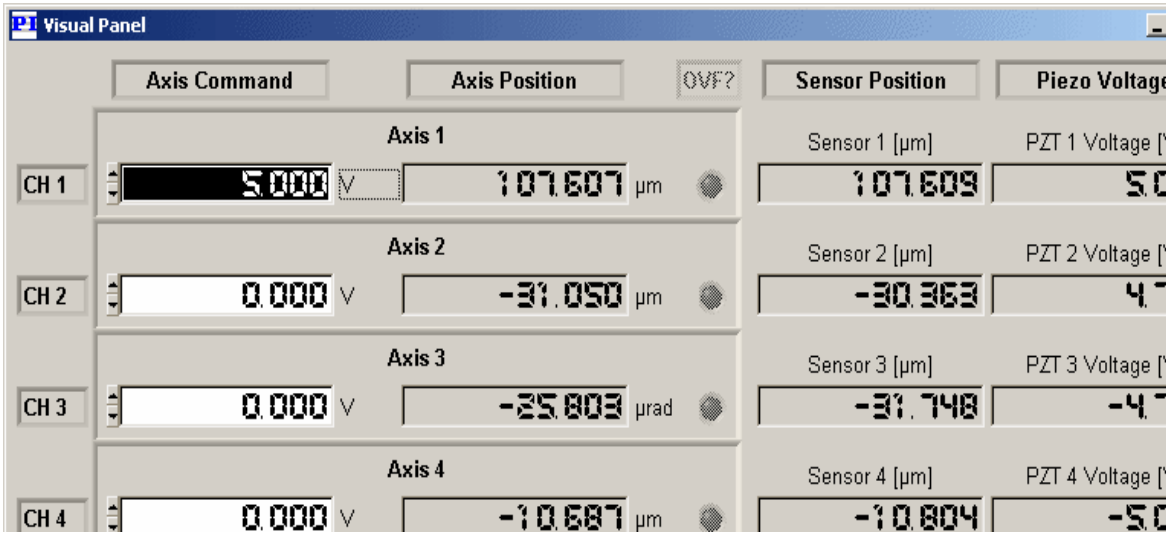


Fig. 16.Visual Panel window. Note that Sensor channel and PZT channel directions are not necessarily parallel to logical axes of the same number

The *Visual Panel* has the following characteristics:

- Depending on your system, one logical axis can affect more than one sensor and more than one PZT. When there is a one-to-one correspondence between logical axes, sensor channels and PZT channels, the respective numeric designations often correspond, but this need not always be the case.
- To command a new value, use the arrow buttons beside a "command" field. You can also change the value of a "command" field and press Enter or leave the field. This is equivalent to sending a move or set voltage command to the respective axis.
- The *Visual Panel* is continuously updated when it is the active window only.

6. Step and Frequency Response Measurements

This Section describes the step and frequency response measurements which can be done from the *Action* pane in the *NanoCapture™* main window, using the appropriate options of the *Current Axis Action* control.

For genuine open-loop devices which do not provide sensor processing electronics (e.g. E-755.101), the *Current Axis Action* control does not contain any step and frequency response options. If you want to make step or frequency response measurements with these devices, select the *Record Table Report* option in the

Current Axis Action control and perform the step or impulse using the appropriate commands in the *Command Terminal*. See Section 9 for more information.

6.1. Configuration

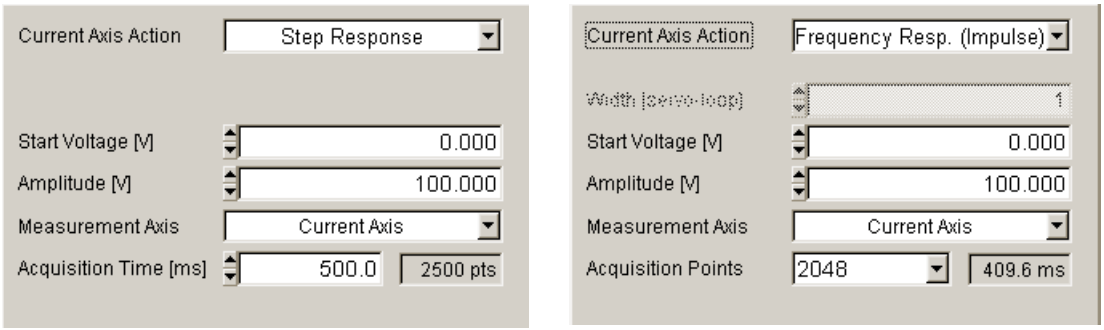


Fig. 17. Settings for open-loop step response and frequency response measurements

The Step or Impulse will be performed on the *Current Axis* in closed- or open-loop mode depending on the servo state of the *Current Axis*.

The measurement parameters that can be set are:

- *Start Voltage* (if servo OFF) or *Start Position* (if servo ON) is the value to which the current axis will be commanded before the Step or Impulse is started, and normally also the value which it will have afterwards. Exceptions: If the axis is in closed-loop mode (servo ON), it is possible to
  - allow only relative motions, starting from the current position. In this case the *Start…* field is not available. See Sections 6.2.2 and 6.3.2 for details.
  - avoid that the axis will return to the *Start Position* after a step motion because this could be very time-consuming. The axis will then keep the final position of the step. See Section 6.2.2 for details.
- *Amplitude* is the commanded amplitude for the Step or Impulse, either in position unit or in volts (depending on the current servo state of the axis).
- *Measurement Axis* can be used to select the axis whose motion is to be recorded and displayed. For the axis which performs the step or impulse, select the *Current Axis* option.

The number of acquisition points (position values to record) and the acquisition time for the measurement are directly linked and depend on the (record) table rate and the servo update time (see Section 5.4 on p. 22). For the *Step Response* you can set the *Acquisition Time* and for the *Frequency Response,* the number of *Acquisition Points*. When the servo is turned on, there will be additional possibilities to optimize acquisition time and record table rate for step response measurements, see Section 6.2.2 for details.

Independent of the servo state (closed-loop or open-loop), during a Step or Impulse response measurement always position data is recorded.

6.2. Step Response

Choose the *Step Response* item from the *Current Axis Action* control, configure the action with the controls displayed below it, then start the step response measurement with the *Start* button (or the F5 key). Unless configured otherwise

(see Section 6.2.2), the axis will be commanded to *Start Position* or *Start Voltage*, a step will be performed and held (at *Start* + *Amplitude*) until recording ends, then the axis will be returned to *Start*. During recording, the position of *Measurement Axis* will be recorded and displayed immediately thereafter on the *Graph* tab card.

If the Servo On box for the axis is unchecked, the step will be performed in open-loop mode, if it is checked, the step will be performed in closed-loop mode.

If you want to stop the step procedure, send an appropriate stop command (GCS commands: #24 or STP) in the *Command Terminal*.

6.2.1. Open-Loop Settings

For an open-loop step response measurement, *Start Voltage* and *Amplitude* are in volts.

The principle governing the choice of these settings is:

minimum axis voltage < (*Start Voltage* + *Amplitude*) < maximum axis voltage.

minimum axis voltage < *Start Voltage* < maximum axis voltage.

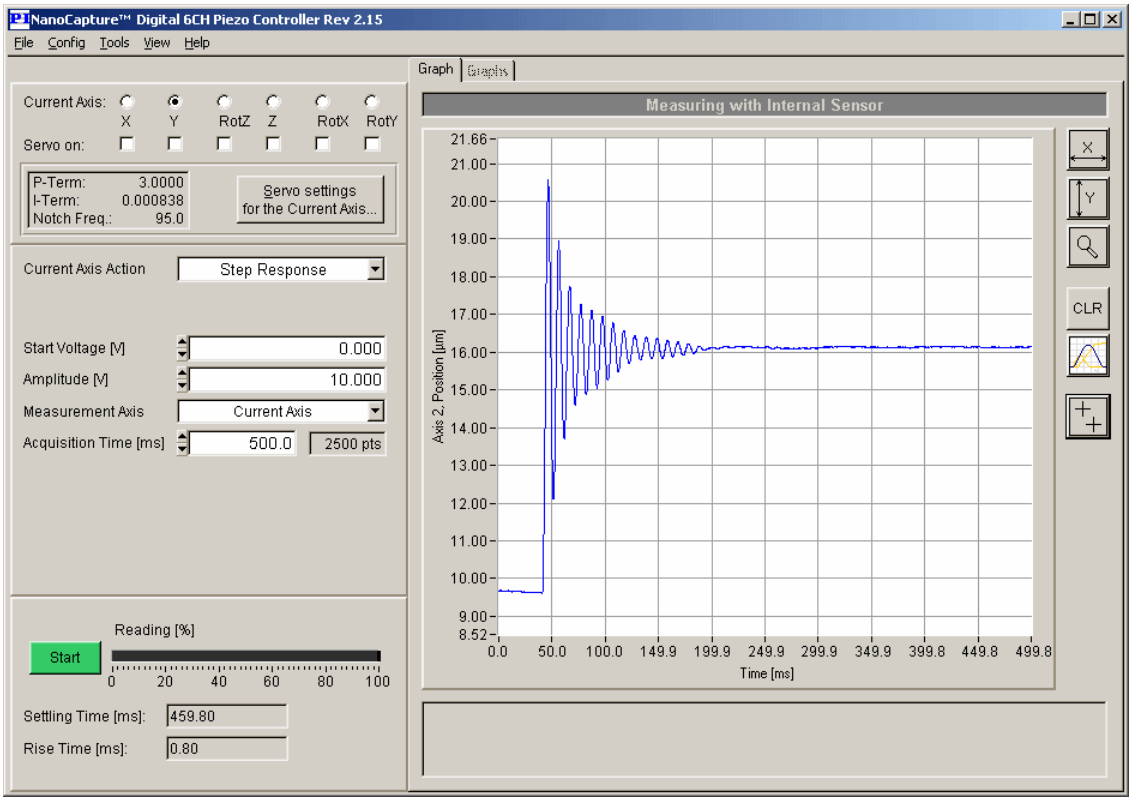


Fig. 18.Open-loop step response

6.2.2. Closed-Loop Settings

For a step response measurement in closed-loop, *Start Position* and *Amplitude* are in µm or µrad.

The principle governing the choice for the setting is:

Range_min < (*Start Position* + *Amplitude*) < Range_max.

Range_min < *Start Position* < Range_max.

Range_min and Range_max are parameters from the Servo Parameter Group.

To optimize the rise time and the settling time, change the servo parameters (see Section 7) and start the measurement again.

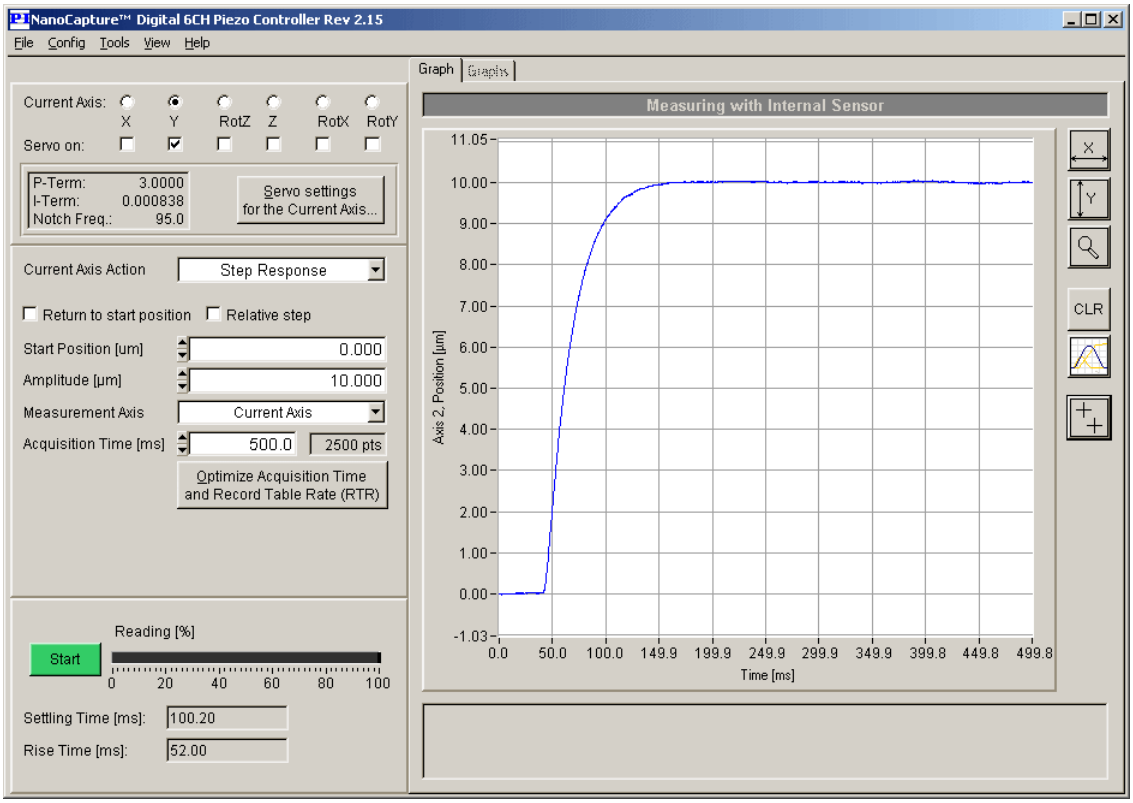


Fig. 19.Closed-loop step response

Usually, the motion for the step response in closed-loop is as follow: the axis is commanded to *Start Position*, a step will be performed and held (at *Start* + *Amplitude*) until recording ends, and then the axis will be returned to *Start*.

With some controllers (e.g. E-755.1A1), this motion can be very time-consuming because, for example, the stage used has a long travel range. For that purpose the controllers closed-loop step response behaviour can be changed using the *Return to start position* and *Relative step* checkboxes (see Fig. 20):

- *Return to start position*: if set, the axis moves to the position were it was before the step was performed, that is to say to the *Start Position* if the *Relative step* option is not set.
- *Relative step*: if set, the step starts from the current position, else the axis is moved to the *Start Position* before the step starts.

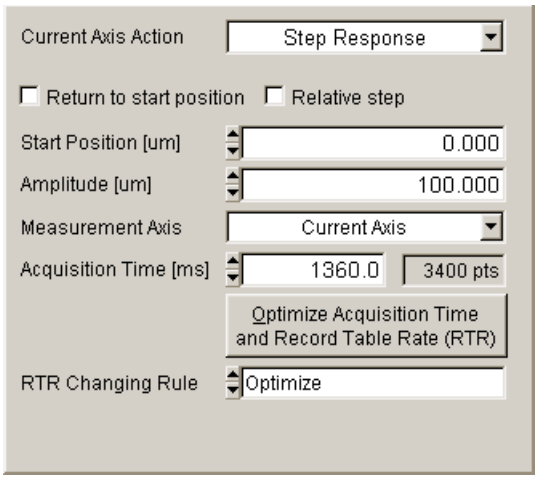


Fig. 20. Optimization controls for of the closed-loop step response behaviour

Depending on the controller used, *NanoCapture™* provides the *Optimize Acquisition Time and Record Table Rate (RTR)* button and the *RTR Changing Rule* control.

With the *Optimize Acquisition Time and Record Table Rate (RTR)* button you can calculate and set the best acquisition time and—if supported by the controller—the record table rate to get the complete step response motion data. The recording may not comprise the complete step response data if

- the commanded axis velocity (GCS commands to set/get: VEL/VEL?) is not reached
- the record table rate is blocked to a small value (depending on the *RTR Changing Rule* selection or if the command level to change the record table rate is not sufficient (see Section 12.2 on p. 57 for more information))
- the maximum number of points that can be recorded is not sufficient to have a larger acquisition time.

The *RTR Changing Rule* control is only available if the controller provides parameters or commands for record table rate adjustment (ID 0x16000000; RTR). It permits to choose the rules which shall be applied when the record table rate is changed for the acquisition time optimization:

- *Do not change*: the current record table rate is taken for the calculation.
- *Optimize*: the minimum needed record table rate for the acquisition is set.
- *Grow only*: does not permit decreasing the record table rate, but larger values will be accepted if required.
- *Shrink only*: does not permit increasing the record table rate, but smaller values will be accepted if required.

6.3. Frequency Response

Choose the *Frequency Response* item from the *Current Axis Action* control, configure the action with the controls displayed below it, then start the frequency response measurement with the *Start* button (or F5). Unless configured otherwise (see Section 6.3.2), the current axis will be commanded to *Start Position* or *Start Voltage* and an impulse will be performed on it.

An “impulse” is a motion from "a" to "b" and then back to "a" after a short time period (width of the impulse).
E-710: This time period is 1 time base interval (Table Rate parameter, usually 1, meaning one servo period).
E-761: The time period can be determined in the *Width (servo-loop)* field.
E-755: This time period is the duration of one processing cycle (0.2 ms for E-755.1A1 and 0.1 ms for E-755.101).

During the *Acquisition time* after the impulse, the motion of *Measurement Axis* is recorded, analyzed and displayed in the form of a Bode frequency response diagram on the *Graph* tab card.

If *Servo On* for the axis is unchecked, the impulse will be performed in open-loop mode; if it is checked, the impulse will be performed in closed-loop mode.

If you want to stop the impulse procedure, send an appropriate stop command (GCS commands: #24 or STP) in the *Command Terminal*.

6.3.1. Open-Loop Settings

For an open-loop frequency response measurement, *Start Voltage* and *Amplitude* are in volts. Choose *Start Voltage* and *Amplitude* values sufficiently far from the limits to avoid sensor overflow:

minimum axis voltage < (*Start Voltage* + *Amplitude*) < maximum axis voltage.

minimum axis voltage < *Start Voltage* < maximum axis voltage.

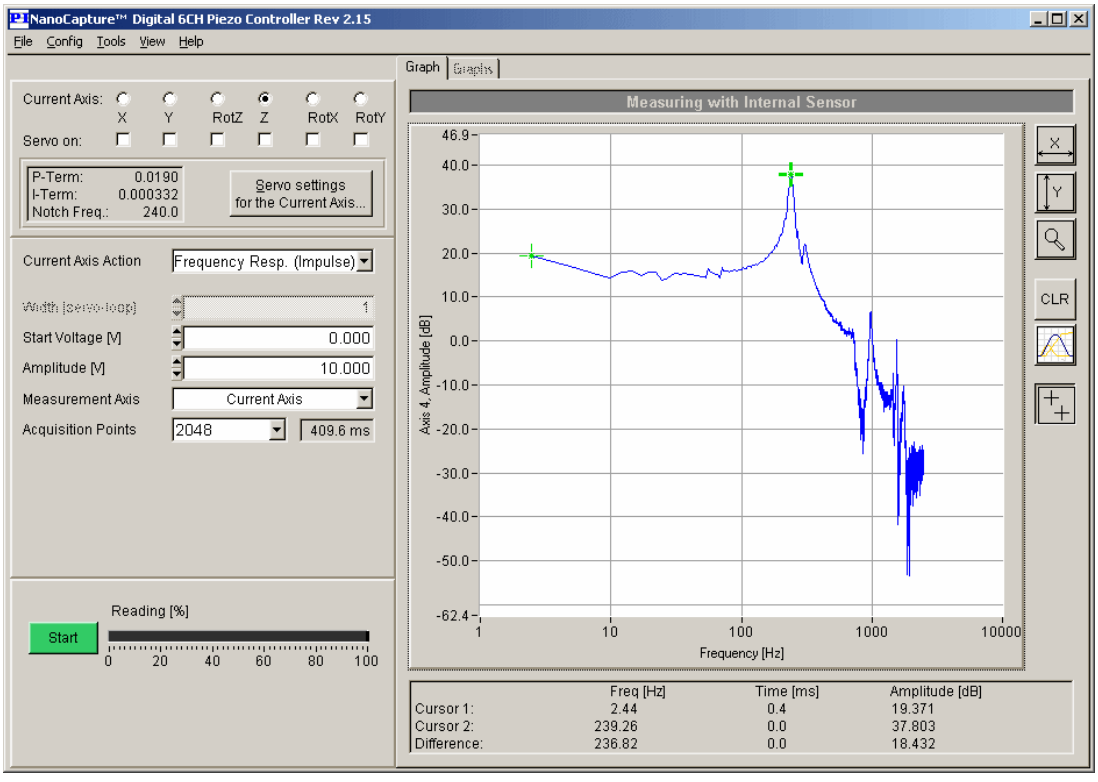


Fig. 21.Open-loop frequency response

6.3.2. Closed-Loop Settings

For a closed-loop frequency response measurement, *Start Position* and *Amplitude* are in µm or µrad.

The principle governing the choice of these setting is

Range_min < (*Start Position* + *Amplitude*) < Range_max.

Range_min < *Start Position* < Range_max.

Range_min and Range_max are parameters from the Servo Parameter Group.

If the notch filter is not set at the resonant frequency value, the Bode plot will show a peak response at that frequency.

Set the notch filter value to the value of the resonant frequency and test again.

See also Section 7.2.1 for instructions on setting the notch filter.

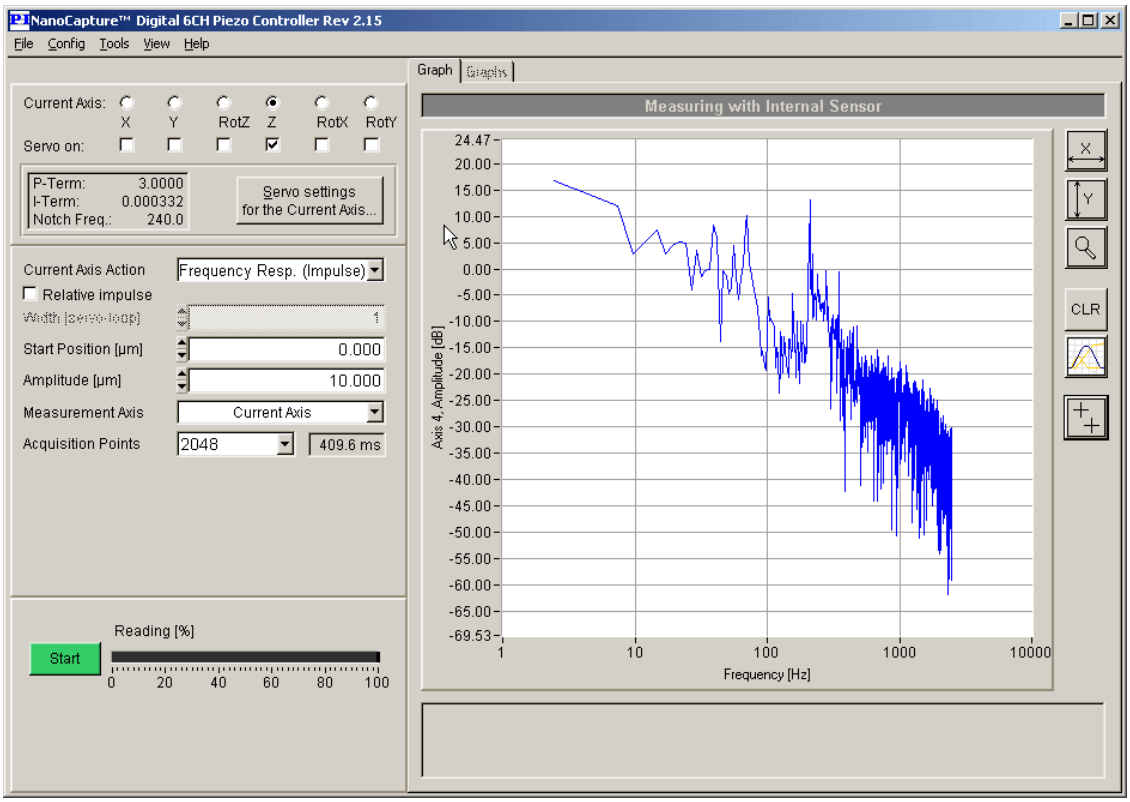


Fig. 22.Closed-loop frequency response

Usually, the motion for the frequency response in closed-loop is as follow: the current axis will be commanded to *Start Position* or *Start Voltage* and an impulse will be performed on it.

With some controllers (e.g. E-755.1A1), the motion to a certain *Start Position* can be very time-consuming because, for example, the stage used has a long travel range. In this case you can activate the *Relative impulse* checkbox (see Fig. 23) to start the impulse from the current position.

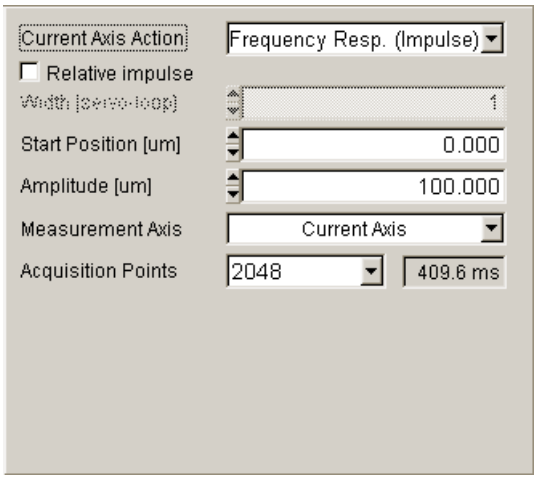


Fig. 23. Relative impulse *checkbox for closed-loop frequency response motions*

7. Servo Parameter Dynamic Tuner

The servo parameter window, the *Dynamic Tuner*, permits easy changing of the main servo parameters for the current axis. It is not provided for genuine open-loop devices which do not contain sensor processing electronics (e.g. E-755.101).

Two versions of this window are available:

- A minimal version for simplicity where only the three most-important and most-often-used servo parameters are available.
- An extended version, displaying more servo parameters, for fine-tuning the system.

Once one of the *Dynamic Tuner* windows is opened, you can easily switch between the versions using the *More…* or *Less…* button.

There are two ways to open the *Dynamic Tuner*

- Click on the *Servo settings for the Current Axis…* button in the main window
- Select the *Dynamic Tuner* item from the *View* menu

7.1. Minimal Dynamic Tuner Window

The three sliders permit changing most-important servo parameters: loop gain, integration term time constant and the frequency of the first notch filter.

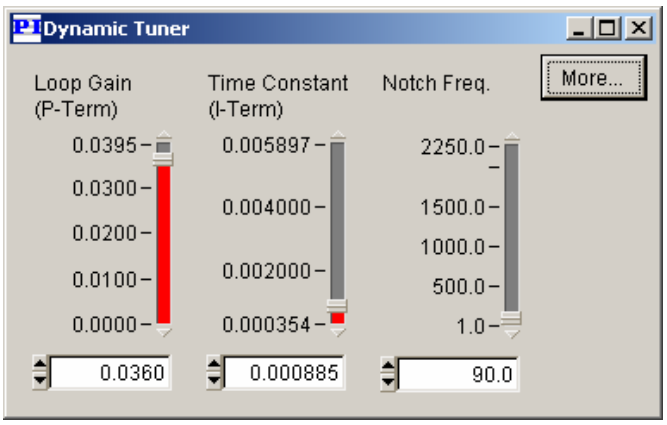


Fig. 24.Minimal Dynamic Tuner with More... button

7.2. Extended Dynamic Tuner Window

Here, 4 more groups of servo parameters can be accessed.

- Input
  - Slew Rate
  - Rise Time
- P-I Controller
  - Loop Gain (P-Term)
  - Time Constant of integrating term (I-Term)
- Notch Filter
  - Notch Frequency
  - Notch Filter Rejection (0.1 means –20db)
- 2nd Notch Filter (dimmed if not available on controller)
  - 2nd Notch Frequency
  - 2nd Notch Rejection

Pressing the *Reset all to defaults* buttons permits resetting the P, I and Notch Filter terms to their default values (stored in the controller non-volatile memory). This can be very useful to restore stable values if changing the servo parameters produces disturbing noises.

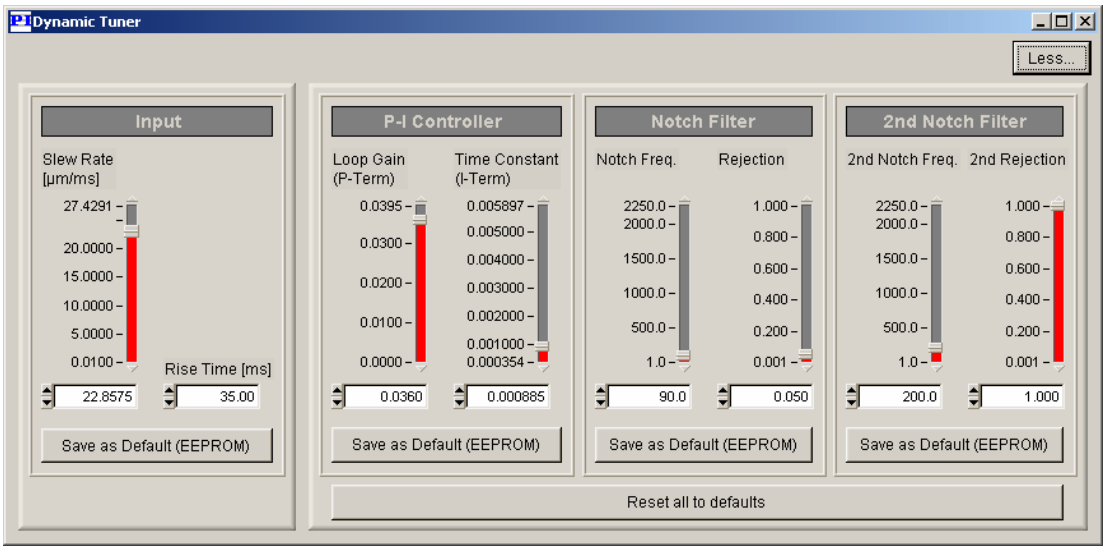


Fig. 25.Extended Dynamic Tuner

7.2.1. Setting the Notch Frequency with the Cross-Hair Cursors

In the extended *Dynamic tuner* window (click *More...* if necessary), the notch filter for the current axis can be set using the cross-hair cursors on the main window frequency response Bode plot:

1. On a Bode plot made in open-loop mode, enable cursor display and enable the cross-hair cursors (Fig. 26).
2. With the mouse, move either one of the cursors to the resonance peak.
3. Make sure the other cursor points to a lower frequency, i.e. that it is to the left of the cursor pointing to the resonance peak.

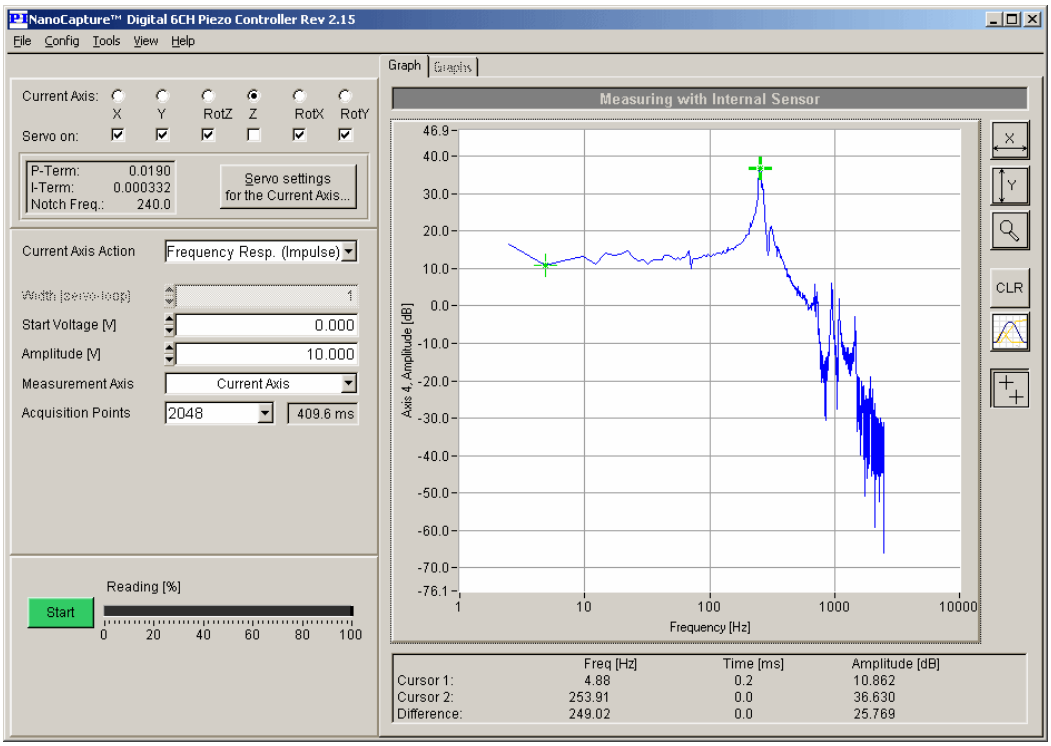


Fig. 26. Cursor positioning for determination of notch frequency

4. In the *Dynamic Tuner* window, right-click on the *Notch Freq.* slider and click on the *Take values from cursors* item on the context menu that appears (Fig. 27). The notch filter frequency will be taken from the cursor which has the higher frequency value.

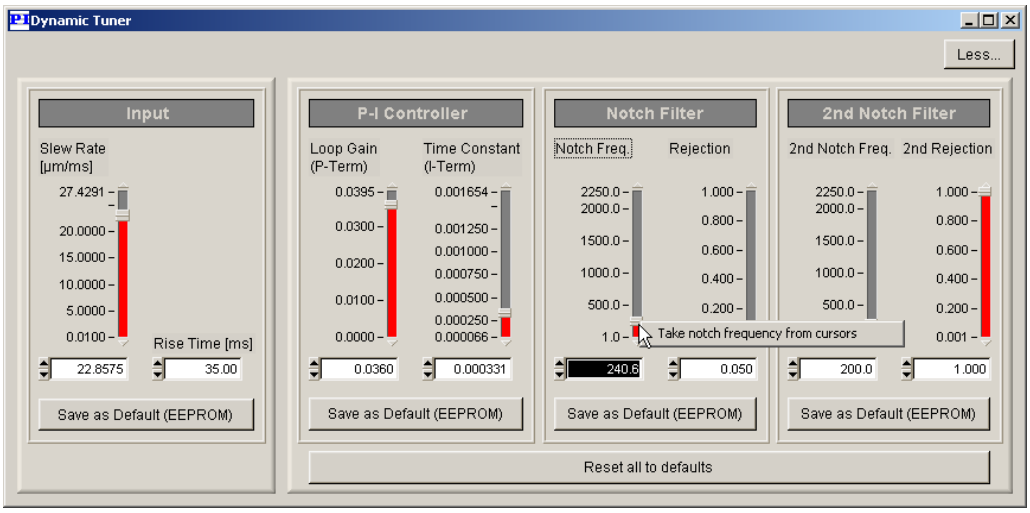


Fig. 27. Slider context menu: used to reset notch filter frequency from the (right-most) cross-hair cursor

5. If desired, repeat this procedure for the second notch filter, if available, using the next higher resonance and the *2nd Notch Filter* slider.

7.3. Changing the Servo Parameters

Servo parameters can be changed with the sliders in both *Dynamic Tuner* window versions.

If you change the notch frequency in either of the *Dynamic Tuner* windows, the time constant will be modified automatically. However, you can also change the time constant separately afterwards.

The sliders can be changed using the ↑ and ↓ arrow keys. Finer increments are possible if you use these keys in combination with the Shift key.

7.4. Saving the Servo Parameters as Default (EEPROM)

As the values set with the sliders are only saved in the RAM, they will be lost at the next power-down or reboot of the controller. To retain these values for the next controller power-up, they must be saved as defaults in the controller EEPROM. To do this, use the corresponding *Save as Default (EEPROM)* button in the extended version of the *Dynamic Tuner* window. If the current command level (CCL level) is too low for the desired operation, an appropriate message will pop up (see Section 12.2. on p. 57 for more information). Note that for stages with ID-chip the option "Read ID-Chip always" (parameter ID 0X0F000000) must be disabled by default to make the optimized settings available in the future.

If these parameters are changed but not saved, the following dialog will pop up when exiting the *NanoCapture*™ to ask about saving them as defaults in the controller.

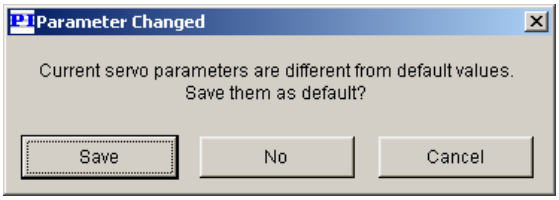


Fig. 28.

Cancel closes the dialog and aborts the exiting process, *No* continues exiting *NanoCapture*™ leaving the differing RAM and EEPROM values untouched where they will available (to *NanoCapture*™ or another program) until the controller is power-cycled or rebooted.

This dialog pops up when ending *NanoCapture*™ whenever any of these servo parameter values in RAM differ from those in EEPROM.

8. Wave Generator

Some E-7XX controllers have built-in wave generators capable of creating, storing and outputting arbitrary waveforms on one axis each. The number of wave generators which are available and able to run simultaneously depends on the controller (see the User Manual of your controller for details).

A waveform can be output once, a fixed number of times, or repeated indefinitely.

E-710: A wave generator outputs relative target values which are added to the target from previous move operations and fed directly into the servo-controller for the axis with which it has been associated.

E-761: A wave generators output absolute values—the output values are not added to the last commanded target value or the last commanded voltage.

When the DDL (Dynamic Digital Linearization) feature is present and activated on the controller, the target values sent from the wave generators can also be pre-adjusted. DDL can reduce tracking error in periodic, dynamic motion by up to three orders of magnitude.

The controller ASCII command set allows more complete control of the wave generator, but the *NanoCapture*™ graphic interface described here is more convenient to use. For a full description of the Wave Generator architecture and the appropriate commands see the controller User Manual and—with E-710—the GCS DLL manual.

CAUTION: Changing any wave generator related settings using ASCII commands in the *Command Terminal* (p. 17) or using the *Device Parameter Configuration* window (p. 46) may affect the *NanoCapture*™ Wave Generator controls described in this section.

Note that the *Time Base Factor* or *Oversampling (AVG)* settings in the *Measurement Setup* window (see Section 5.3, p. 20) affect the servo update time and hence the operation of the wave generators.

There are two methods of controlling the Wave Generator with the *NanoCapture*™ GUI: a simplified one and an advanced one. Either method allows defining at least one *waveform* and outputting a wave to an axis.

8.1. Simplified Waveform Interface

From the list in the *Current Axis Action* control on the main screen, choose the *Simple Waveform* item and configure it (for the current axis) with the controls that appear below it.

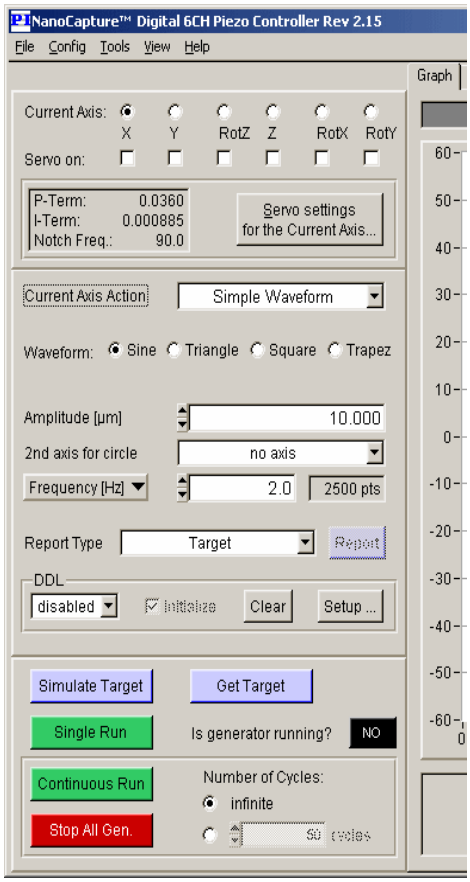


Fig. 29.Simple Waveform definition

8.1.1. Waveform Definition

- Select a waveform (sine wave, triangle wave, square wave or trapezoid wave) using the radio buttons. If you select the sine wave, you have the option of selecting a second axis (*2nd axis for circle*) and driving it with a 90-degree-shifted version of the waveform. If the axis selected there is orthogonal to the *Current Axis*, a circular motion in the plane of the two axes will result when the output is started.
- Enter *Amplitude* and *Frequency* (or click the down-arrow beside *Frequency* and choose *Time* to enter the period) for the selected waveform.

8.1.2. Report Type

The type of data to gather during waveform output is specified here. See Section 8.2.6 for details.

Note that for some controllers (e.g. E-710) the target values obtained with *Simulate Target* or *Get Target* may contain the starting position or move command contribution thereto (see the controller User Manual for details).

8.1.3. DDL Settings

When the DDL (Dynamic Digital Linearization) feature is present on the controller, the DDL configuration is managed through the DDL controls in the pane just above the *Simulate Target* button (otherwise the pane is dimmed):

- The *disabled / enabled* selection box permits disabling / enabling DDL.
- The *initialize* check box permits reinitializing DDL while the generator is running.
- The *Clear* button permits erasing the *Waveforms* and DDL data.
- The *Setup…* button opens the *DDL Setup* window, which is described in Section 8.2.4 below.

8.1.4. Wave Output

The waveform can be output to the current axis (and a second axis, if configured) with the buttons in the bottom panes (for detailed description, see Section 0).

8.2. Advanced Waveform Definition

Because the *Advanced Waveform* controls aim to offer more possibilities to the user, more parameters must be specified explicitly. The controls leading to them appear when you choose *Advanced Waveform* in the *Action* field of the main window. Note that most controls remain dimmed until at least one waveform has been defined, and that the *Current Axis* specification is not imposed.

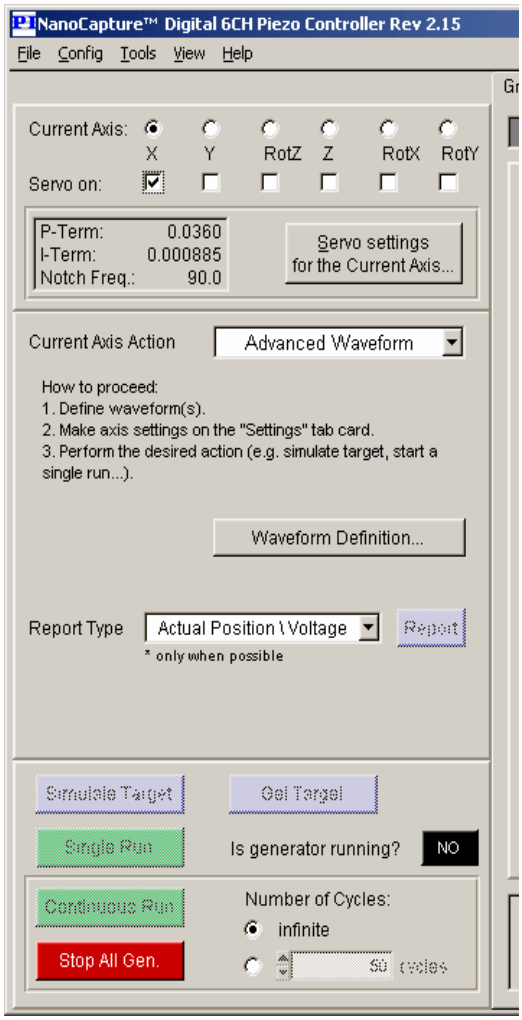


Fig. 30.Advanced Waveform main screen controls with no waveforms defined

8.2.1. Overview

1. First use the *Waveform Definition…* button to open a window (Fig. 31) which makes it possible to define one or more *waveforms* consisting of multiple concatenated *segments,* with each segment containing a *curve* that you select.
2. Use the *Settings* tab card (see p. 43) to assign each *waveform* to a logical axis, clear the DDL (dynamic digital linearization) table and set DDL parameters, if desired.

Return to the main window and start the wave generator output on the specified axis or axes with the *Single Run* or the *Continuous Run* button.

8.2.2. Waveform Definition Window

Opened by a main window button, the *Waveform Definition* window facilitates defining of *waveforms*. A *waveform* is a concatenation of *segments*, and each *segment* contains one *curve*, which can be scaled and positioned as desired in the segment.

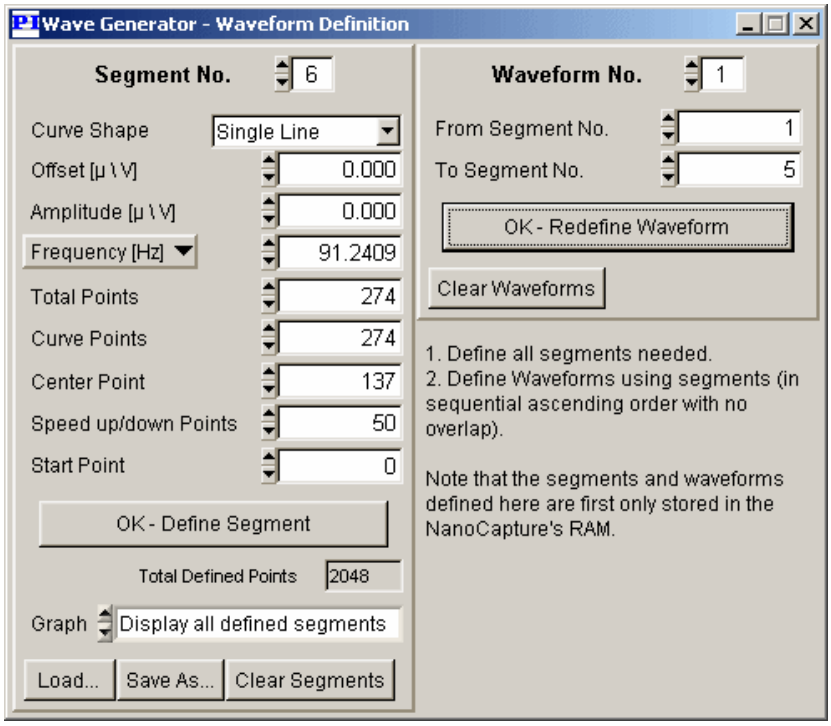


Fig. 31. Window opened by the Waveform Definition button on the main screen (Advanced Waveform must be selected in the main screen Action field)

8.2.2..1 Defining Segments

The left-hand pane of the *Waveform Definition* window grants access to all the parameters available to define a segment. After choosing a *Curve Shape* and entering the parameters for it, press *OK - Define Segment*. Note that *Offset* permits moving the *Curve* physically "up" or "down" (in position), whereas *Start Point* moves it temporally (in time) in the segment. (E-710 only: Set *offset* to zero for any segments that are destined to become the first segment of a waveform. Otherwise the segment may be adjusted by the GCS DLL and some displays may be shifted.) The segment will be stored in *NanoCapture™'s* RAM and represented on the *Graph* tab card. The segment number will also be incremented and the fields readied for input of the data on the next segment. The segments will be concatenated in numerical order, as seen on the *Graph* pane if *Display all segments* is selected in the appropriate selection box.

The *Save As…* button permits you to save all the segments which have already been defined in a directory and filename of your choice for later use. The definition currently on the screen is included only if it has been previously saved with *OK - Define Segment.*

With the *Load…* button you can load a previously defined set of segments. You can either load a segment set from the samples (in the application directory, in the *\Samples* subdirectory) or one you have previously defined and saved. CAUTION: A load operation clears the complete segment/waveform definition in *NanoCapture™'s* RAM and redefines all segments as in the loaded file.

The *Clear Segments* button clears the current segment definitions and permits restarting the segment definition process with segment 1.

Choosing between *Display all defined segments* and *Display one segment* in the associated selection box affects the display in the *Graph* tab card of the main window. Note that with *Display one segment* only one segment is shown and the segment must have been defined before by pressing the *OK – Define Segment* button.

8.2.2..2 Defining Waveforms

The right-hand pane of the *Waveform Definition* window is for defining *waveforms*. A *waveform* consists of the concatenation of one or more *segments*, in sequential order. *Waveform 1* need not begin with *segment 1*, but *waveform 2* must begin with a *segment* one-higher than the last *segment* of *waveform 1*, etc.

Enter the numbers of the first and last segment of the waveform to be defined in the *From Segment No.* and *To Segment No.* fields. (E-710 only: The first segment of a waveform should have been defined with *offset* = 0.)

The *OK - Define Waveform* button stores the definition of the waveform in *NanoCapture™'s* RAM. The *waveform* number will also be incremented and the *From and To* fields readied for input of the next *waveform,* and so on until the last definable waveform. The maximum number of *waveforms* that can be defined with *NanoCapture™* depends on the controller and its GCS DLL.

The *OK - Redefine Waveform* appears when the displayed waveform has already been defined

The *Clear Waveforms* button clears all the current waveform definitions and permits restarting the waveform definition process with *waveform 1*.

8.2.3. Axis Selection and DDL Settings

The *Settings* tab card automatically becomes active when the *Waveform Definition* window is closed.

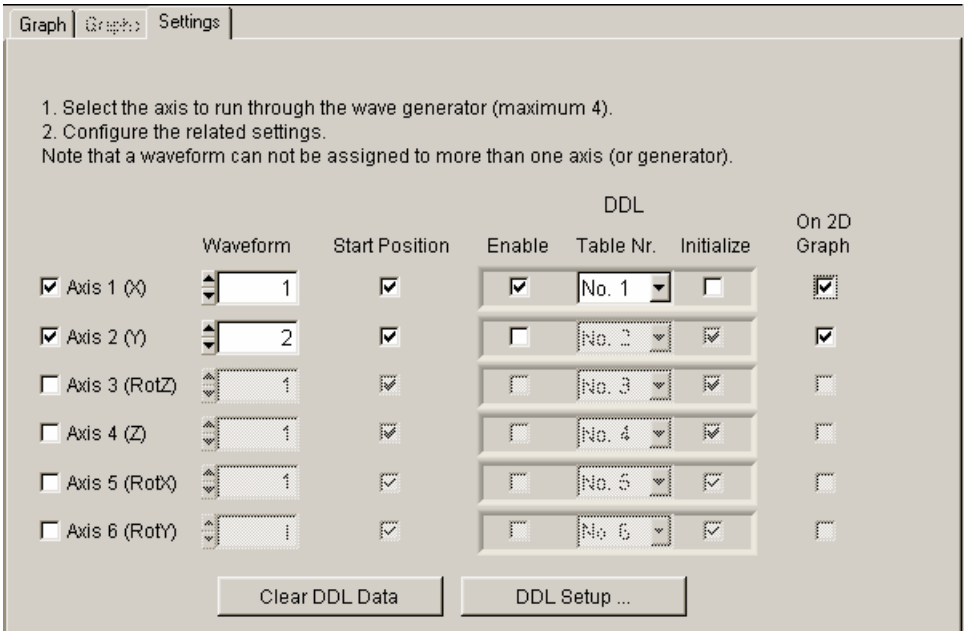


Fig. 32: Wave Generator Settings *tab card. Available on the main screen when* Advanced Waveform *is selected in the* Current Axis Action *field.*

The axes to be used with a wave generator must be activated with the associated checkboxes and then a different waveform must be assigned to each.

E-761 only: Since the controller supports 3 logical axes but has 4 wave generators, the output of the 4th wave generator can be made available on the 4th piezo channel of the controller. See E-761 User Manual for more information.

E-710 only: The [return to] *Start Position* checkboxes permit specifying whether any difference between the first and last position (after each period) is to be added to the start position of the next-period motion or not.

The *DDL* controls on this screen are as follows (dimmed if the DDL feature is not present on the controller):

- The *Enable* checkboxes permit enabling/disabling the DDL use for the axis.
- The *Table No.* selection box permits choosing the DDL data table associated with this axis. (only available for E-710)
- The *Initialize* checkboxes permit reinitializing the associated DDL table while the generator is running.

The *Clear DDL Data* button permits erasing the DDL data.

The *DDL Setup…* button opens the *DDL Setup* window, which is described in Section 8.2.4 below.

The *On 2D Graph* checkboxes permit choosing two axes whose results will be displayed on the *Graphs* tab card. This tab card provides two graphs for the individual axis results and one graph containing the results for both graphs (2D). The results of any other axes will all be displayed as one-dimensional graphs on the *Graph* tab card. See Section 4.4 on p. 15 for more information about graphic reports.

8.2.4. DDL Setup

Note that this window is only available when the DDL (Dynamic Digital Linearization) feature is present on the controller.

Opened with the DDL Setup on-screen button, the *DDL Setup* window allows setting the various DDL parameters available. See the controller User Manual for a discussion of how DDL can virtually eliminate tracking error in periodic motion* and for a detailed description of these values and how to use them. Changed values are stored in controller RAM immediately.

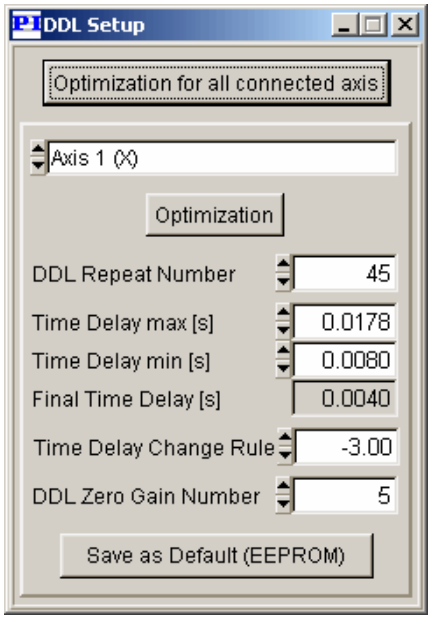


Fig. 33.DDL Setup window

The window also has the following buttons:

- *Optimization***
- *Optimization** for all connected axes*
- *Save as Default* makes the changed values available after the next power up of the controller.

Close the window with the standard close button .

8.2.5. Generator Run

- *Simulate Target* draws a graph with the target positions calculated by *NanoCapture™* (therefore no device needs to be connected for this)
- *Get Target* reads the target positions from the controller without performing any motion.

Note that because of the different sources for *Simulate Target* and *Get Target*, the values in the display may differ slightly.

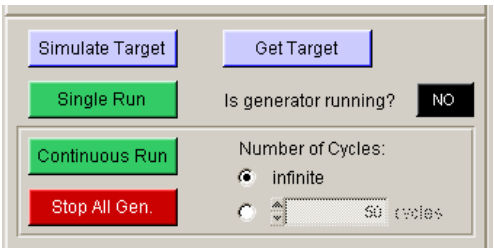


Fig. 34 Generator Run pane in main screen

- *Single Run* starts a single cycle of wave generator output.
- *Continuous Run* starts a specified fixed, or indefinite number of wave generator output cycles, depending on what is specified at the right of the pane.
- *Stop All Gen.* permits stopping the wave generator output for all generators that are running.
  CAUTION: When multiple wave generators are running, they are stopped one after another, but not synchronously.

The *Is generator running?* indicator shows the generator state.

CAUTION—E-761 only: *Stop All Gen.* also reconfigures all wave generators so that they will start the output with the first point of the appropriate waveform when running for the next time. Depending on the current position on wave generator stop, this may cause a jump to the start position when the output is started again.

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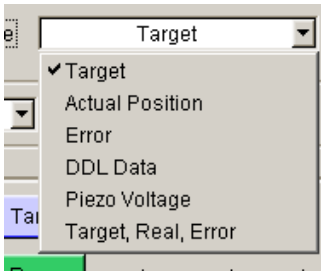
* DDL is standard on 6-channel E-710s but an option on other E-710s. An E-710 without DDL can be upgraded over the interface without opening the controller case. See the DDL license status command description in the E-710 User Manual for details.

** Requires command level 1, see native LP command in E-710 User Manual

8.2.6. Data Reporting



The controller can record data while the Wave Generators are running. Use the *Report Type* selection box to determine the data you want to have recorded on the next generator run.

Available data types depend on the controller, e.g. *Target*, *Actual Position* and *Error*. In *Continuous Run* mode, under some conditions, *DDL Data* and *PZT Voltage* can also be recorded (not with E-761).
E-761: Only the position is actually recorded. The reported position error is not measured but calculated as follows:
Error = Target - Position.

When the generator output is started with *Single Run*, *NanoCapture™* automatically displays the data recorded on the *Graph* and *Graphs* tab cards (depending on the 2D settings on the *Settings* tab card, see Section 8.2.3 on p. 43).
When the generator output is started with *Continuous Run*, you can change the *Report Type* during the run. To record and display the corresponding data on the *Graph(s)* tab card, press the *Report* button.
Simulate Target and *Get Target* do not cause a move but only the display.

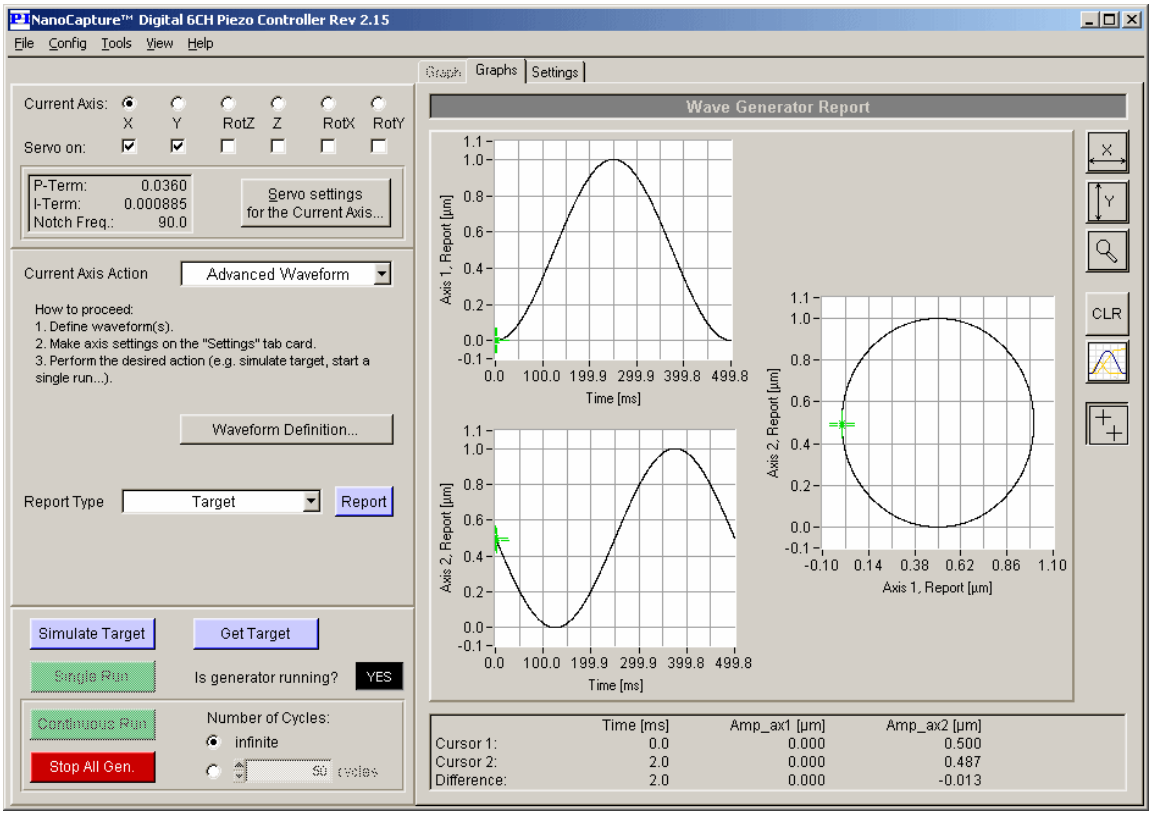


Fig. 35.Wave Generator Report on the Graphs tab card

The *Report Type* list entry "*Target, Real, Error*" permits reporting three data types.
E-710: Note that the corresponding report will contain three curves that correspond to three different run cycles.

Depending on the data type displayed, the curve in the *Graph(s)* tab card will have a different color: the target position will be reported in black, the actual position in blue and the position error in red. Other curves will be reported in blue.

9. Record Table Report

The availability of the *Record Table Report* option depends on the controller used. This option provides an easy way to configure data recording operations and to read out the recorded data. Depending on the controller used it is possible to assign record options and data sources to the data recorder tables, and to set trigger options to determine in which case recording takes place (usually, performing a step or impulse or starting a wave will trigger the recording). For more information, see the descriptions of the appropriate GCS commands in the controller user manual.

The *Record Table Report* option is accessible from the *NanoCapture*™ main window by choosing the corresponding item in the *Current Axis Action* control. If you choose *Record Table Report*, the *Record Tables* tab card becomes available in the Graphic Report / Settings field.

On the *Record Tables* tab card, you can see/set the record table settings and triggers (if supported by the controller). Proceed as follows to configure data recording:

1. In the *Record Table* column, select the record tables you want to configure. Deselected lines will be dimmed.
2. In the *Record Table Configuration* pane:
   a) Set the desired record option, i.e. the kind of data to be recorded, for all selected record tables.
   b) Set the data source (e.g. a certain axis or piezo channel) for all selected record tables.

   Notes

   Depending on the controller used, the assignment of record options and data sources to the record tables may be fixed.

   The available record options depend on the controller used.

   The available number of data sources depends on the selected record option. E.g. if the record option is "Real Position", the axes present on the controller will constitute the available data sources, while for "Piezo Voltage" the amplifier channels of the controller will be the data sources.

   See the User Manual of your controller for more information regarding the available options.
3. In the *Trigger Configuration* pane, choose the trigger conditions for data recording.

   Notes

   The *Trigger Configuration* pane is dimmed if the controller does not support any record trigger configuration.

   The available trigger sources depend on the controller used.

   The content of the *Value* column is irrelevant if *Trigger Source* < 3.

   See the User Manual of your controller for more information regarding the available options.
4. Accept or discard the changes: to discard them and restore the last valid settings, press the *Get Current Settings* button. To make the changes the new valid settings, press either the *Accept Settings* buttons in the panes or the *Accept All Settings* button.

To start an action which triggers data recording, open the *Command Terminal* and send the appropriate command (e.g. the GCS command STE for step response measurement or IMP for impulse response measurements; see the controller User Manual for more information).

After a record action has taken place, on the *Action* pane you can select the *Record Table no.* you want to get from the controller and the *Number of Points* that have to be read. Then press *Get* to get the data. The data will be displayed on the *Graph* card.

The results can be saved to a *.dat file on the host PC using the *File → Save As* menu sequence and loaded again later on.

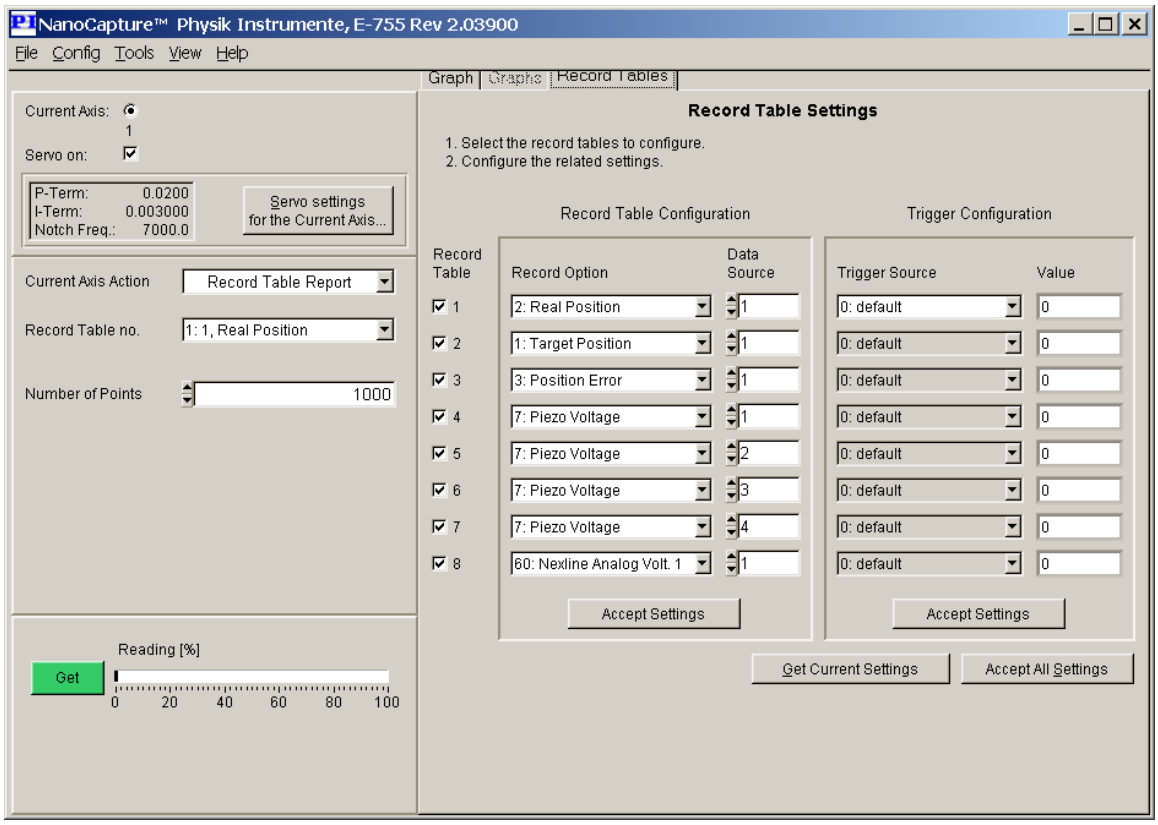


Fig. 36.Data recorder settings on the Record Tables *tab card*

Note

The settings on the *Record Tables* tab card may be changed automatically when one of the following actions is performed via the appropriate *Current Axis Action* option in the *NanoCapture™* main window:

→ Starting any wave generator

→ Starting a step or frequency response measurement

10. Device Parameter Configuration

To adapt the system to your application, you can modify parameter values—either for the whole system, for individual axes or for individual sensor channels and PZT amplifier channels (for the interdependence between axis and channels see the controller User Manual). The parameters and parameter types available depend on the controller firmware. They are listed in the *Device Parameter Configuration* window of *NanoCapture*™ (Fig. 38 on p. 50). To open the *Device Parameter Configuration* window, select the *Device Parameter Configuration* item from the *Config* menu.

In this window, parameter values from the controller's active settings (RAM values) are displayed. The settings can be edited and saved to the non-volatile memory (EEPROM), but in contrast to many other windows in *NanoCapture*™, changes are not sent immediately to the controller, but first held in an *Edit Mask* column. Note that PI records data files of every E-7XX controller calibrated at the factory for easy restoration of original settings after shipping. Note that for stages with ID-chip the option "Read ID-Chip always" (parameter ID 0X0F000000) must be disabled by default to make any optimized settings that were saved to non-volatile memory available in the future.

There are too many parameters to display all on one screen. Therefore, the parameters are grouped under different headings. In the toolbar, a selection control permits choosing the type of parameters that will be displayed in the window (Fig. 37 on p. 49).

Note that many parameters have a password protection. The protection status of the individual parameters can be seen in the *CCL* column of the *Device Parameter Configuration* window. See Section 12.2 on p. 57 for password information.

Note that the *Chan*. column of the *Device Parameter Configuration* window always shows the **index** of the axis / sensor channel / PZT amplifier channel related to the parameter and **not** the axis or channel **names** (e.g. the axis names set with the SAI GCS command). These indices are also present in the group headings which are used for parameter type selection (see above). Example: Axis *1* was renamed to *A*, but the axis related servo parameters are still grouped under the *Servo 1* heading, and the *Chan*. column still contains the value *1* and not *A*.

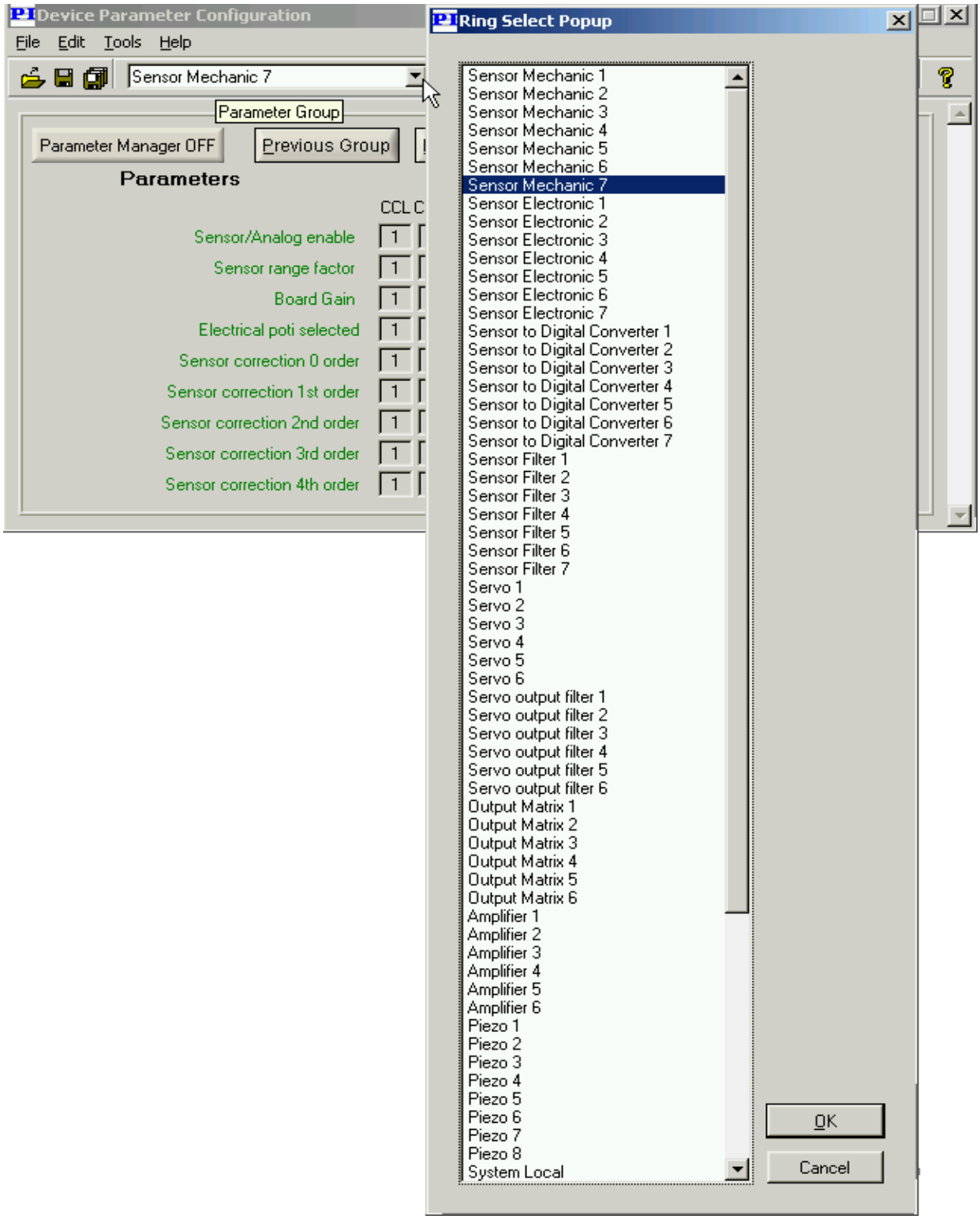


Fig. 37. Device Parameter window with parameter group list open

You have several options to handle the parameter values (See Section 10.3 on p. 52 for the appropriate menu items and buttons):

- You can load/save parameters from/to a file. Loaded parameter values will be written to the *Edit Mask,* and only the values in the *Edit Mask* column can be saved to a parameter file. To save the *Current Settings* or the *Default Settings* you have to copy them first to the *Edit Mask* and then save to a file.

- To write a new value to the controller, write it in the corresponding *Edit Mask*, select it and then use the appropriate write function. Multiple selections are possible. Only the selected *Edit Mask* values will be written to the controller. CAUTION: Wrong values may lead to improper operation or damage of your hardware!
  - For test purposes, write the value to the *Current setting* (RAM). After that, the corresponding *Current Setting* value will be displayed in red.
  - If you write the value to the *Default Setting*, the value will be saved in the controller's EEPROM, that is, in the non-volatile memory of the controller. E-710 only: Writing to the EEPROM changes also the RAM value.
- You can compare the parameter value from the *Current Setting* (RAM) with the one from the *Default Setting* (EEPROM) using the *Compare Current Setting with Default Setting* menu item. Parameters that are different in RAM and EEPROM when you perform this comparison are then displayed in red in the *Current Setting* column. This comparison is automatically performed in the *Device Parameter Configuration* window whenever the parameters are uploaded from the firmware.

10.1. Parameter List Controls

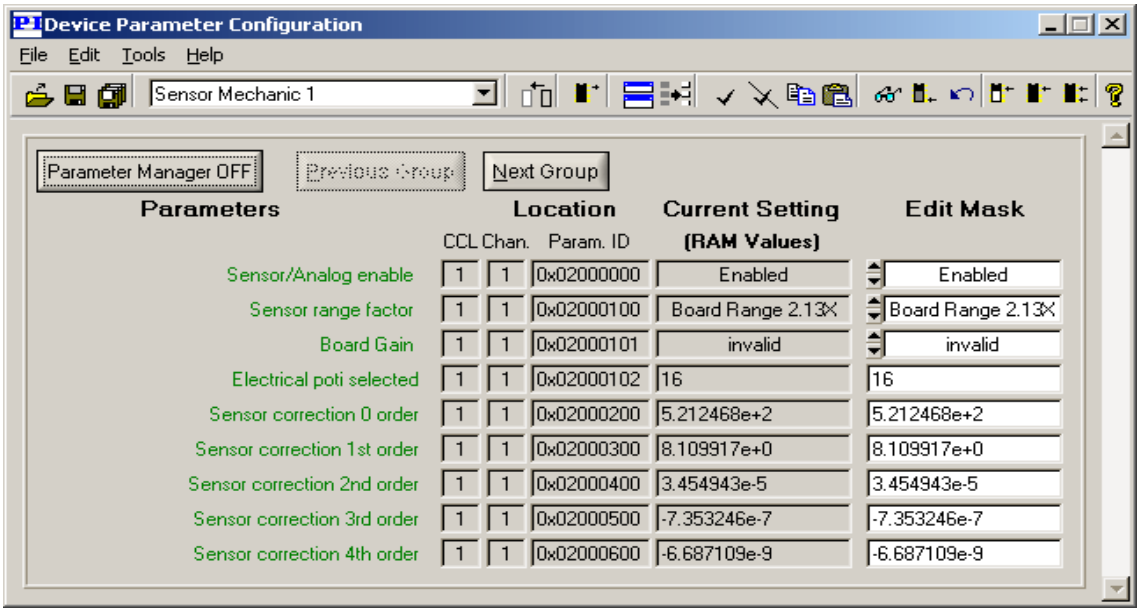


Fig. 38. Device Parameter window with Sensor Mechanic 1 selected.

In the *Device Parameter Configuration* window there are the following buttons available for parameter list control and parameter management:

- *Previous Group* and *Next Group* buttons, which permit paging through parameter groups faster than using the *Parameter Group* selection box.
- *Parameter Manager:* indicator/button, when OFF indicates that the *Parameter Manager* functions are hidden and the *Parameter Lists* are displayed. Clicking it reverses the situation, displaying the *Parameter Manager* controls and hiding the *Parameter Lists.* The *Parameter Manager* controls are described below in Section 10.2.

10.2. Parameter Manager Controls

Using the *Parameter Manager* controls, you can easily copy the values of selected parameter types, and it is also possible to copy the default settings (EEPROM values) to the *Edit Mask*, which is not possible with the menu items and buttons described in Section 10.3.

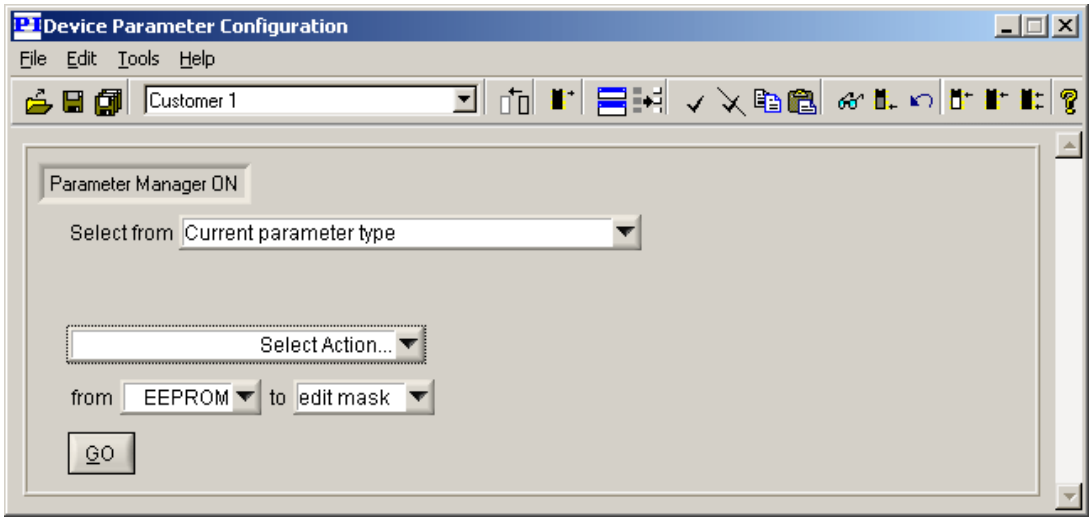


Fig. 39:

- *Parameter Manager indicator/button* when ON, indicates that the *Parameter Manager* controls are displayed and the parameter list is hidden; it also permits toggling back to the *Parameter List* controls.
- In the *Select from* selection box, the user selects the parameter type to work with (see Fig. 40).

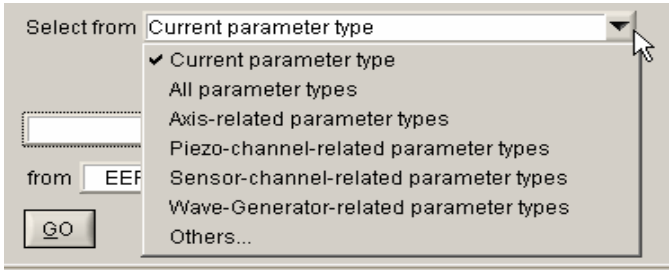


Fig. 40 Select from list box with list open

The other selection boxes permit defining the action to perform, that is: copying the values of the concerned parameters from EEPROM, RAM or Edit Mask to RAM or Edit Mask.

The pane layout changes depending on what is in the *Select from* selection box. *Current parameter type* refers to that selected in the *Parameter group* list control.

If the selection is not *Current parameter type*, the pane contains:

- Check boxes for choosing all concerned parameter types to take into account for the action to perform.
- An *All* check box that permits taking all the concerned parameter types into account for the action to perform.

If the selection is neither *Current parameter type* nor *All parameter types*, the pane also contains a selection box permitting you to choose all or a single axis / piezo channel / sensor channel / wave generator, depending on the action to perform.

The selected action will be performed on the corresponding parameters when pressing the *Go* button.

An example of the *Parameter Manager* pane configuration for copying all sensor-channel-related parameters from EEPROM to the *Edit Masks* is shown in Fig. 41

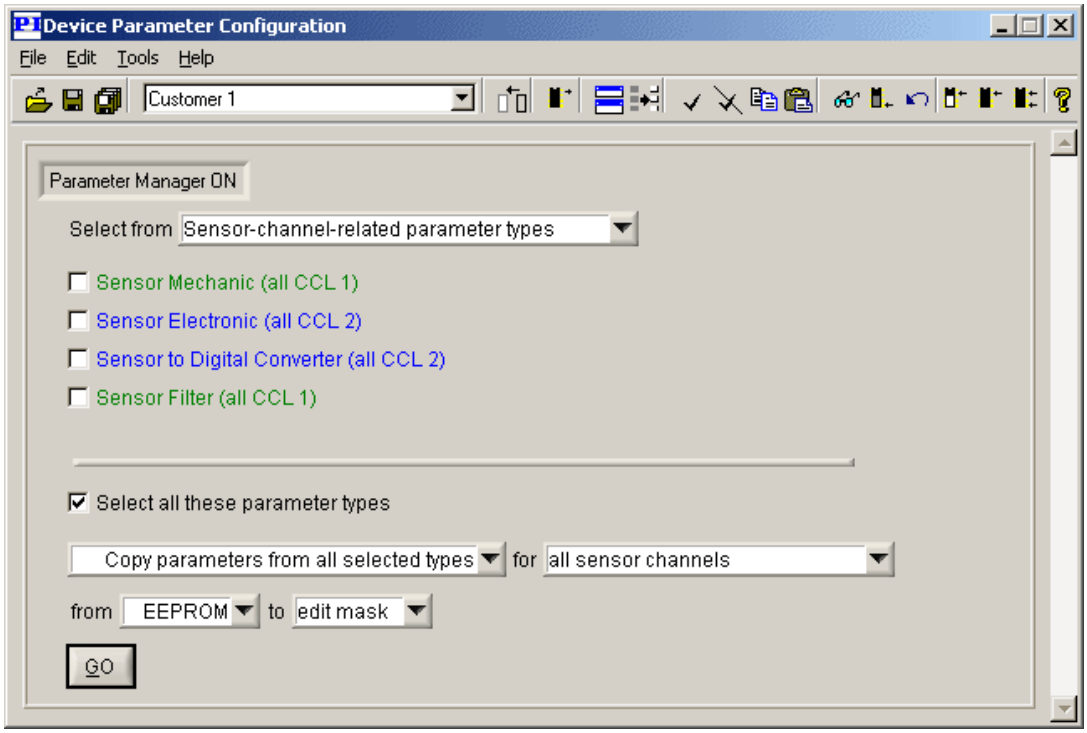


Fig. 41.

10.3. Menu Bar and Toolbar

Most of the menu items are available on the toolbar, and all icons are available on the menus.

10.3.1. Menu Bar Items

10.3.1..1 File

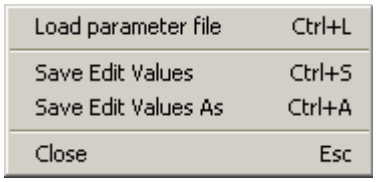


Fig. 42.

- *Load parameter file* permits loading all parameters from a parameter file (with the extension .pam) and writing them in the corresponding *Edit masks* field.
- *Save Edit Values As* and *Save Edit Values* permit saving all parameters from the *Edit Masks* into a parameter file.
- *Close* permits closing the *Device Parameter Configuration* window.

10.3.1..2 Edit

Fig. 43.

- *Copy* permits copying the selected parameter *Edit Mask* values from the current parameter type to the clipboard.
- *Paste* permits writing the parameter saved in the clipboard to the same position in the Edit Mask of the current parameter type. The parameter type where the parameters have been copied from and the one were the parameter will be pasted must be compatible. If the parameter types are not compatible the following message will pop up.

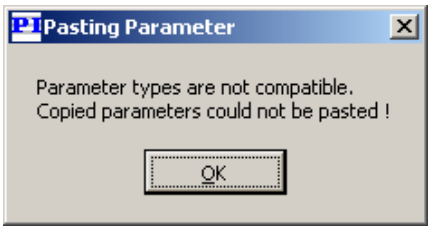
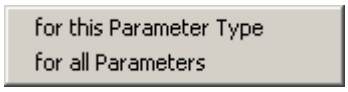


Fig. 44.

- *Select all* and *Deselect all* permit selecting or deselecting all *Edit Mask* values. In both cases, this applies either to the current parameter type or to all parameters, depending on what you select in the associated submenu.



Note: Individual parameter edit values can be selected by pressing the left mouse button or deselected by pressing the right mouse button. Selected parameters are displayed in white in a grey background. Only selected parameters will be used in write operations.

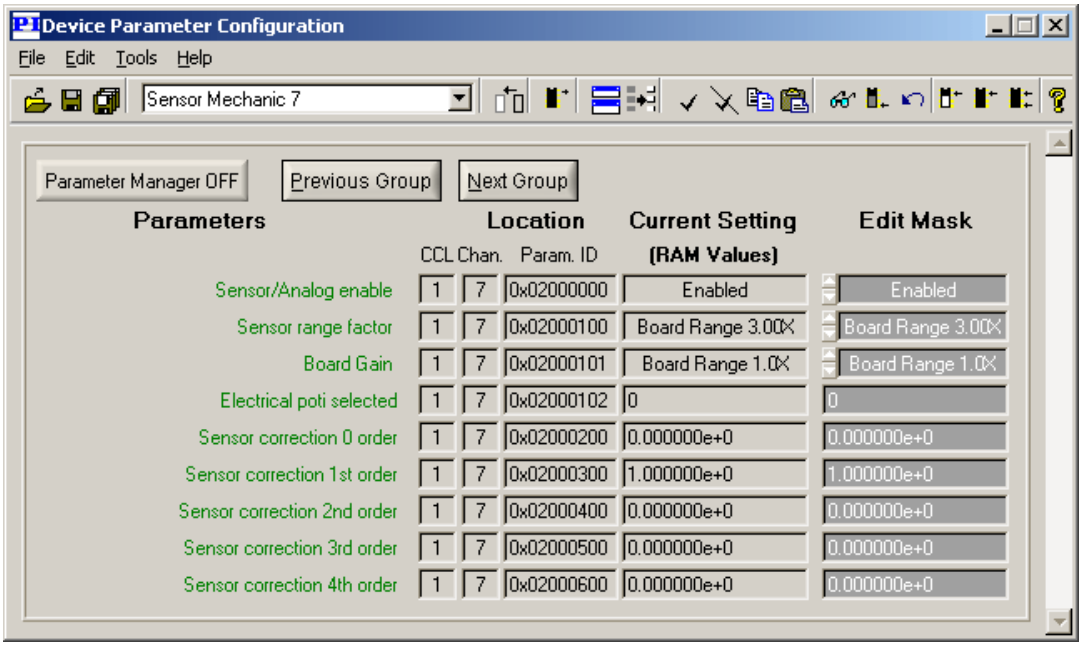


*Fig. 45.*Sample configuration window where all *Edit Mask* values from the current parameter type have been selected.

10.3.1..3 Tools

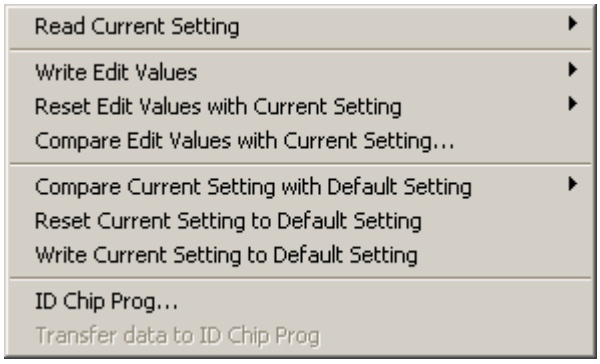
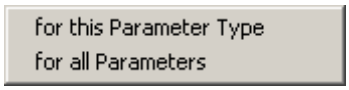
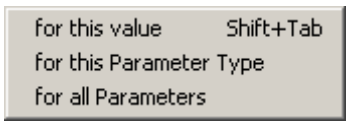


Fig. 46.

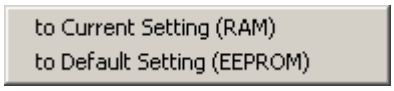
- *Read Current Setting* permits reading the RAM values from the controller for either the current parameter type or for all parameters, depending on what you select in the associated submenu:



- *Reset Edit Values with Current Settings* permits resetting the values in the *Edit Masks* to the values from the *Current Setting* column. This applies either to the parameter that is currently activated with the cursor or to all parameters from the current parameter type, or to all parameters, depending on what you select in the associated submenu:



- *Write Edit Values* permits writing values in the *Edit Mask* to either the controller RAM or EEPROM, depending on what you select in the associated submenu:



- *Compare Edit Values with Current Setting…* permits comparing the values in the *Edit Mask* with the RAM values for all parameters. At the end of this action, a dialog gives you access to precise information about the parameters that differ, for example.

Pressing the *Details…* button opens a dialog box with more information about the first parameter that differs and a *Next* button for moving on to the next parameter (Fig. 48*)*.

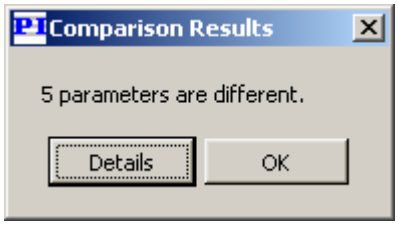


Fig. 47.

As you go through the different parameters, the parameter type from each parameter is made the *current parameter type* in the *Device Parameter Configuration* window, and the parameter in question is highlighted (selected), so that it can easily be found.

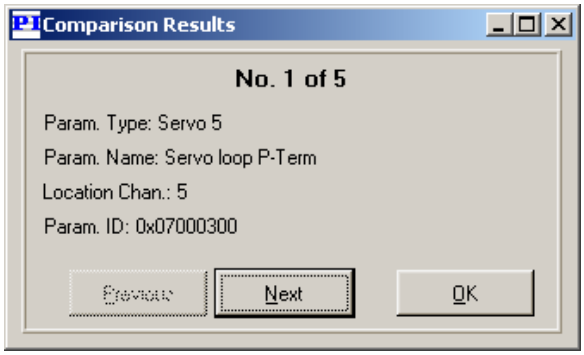
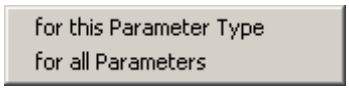


Fig. 48.



- *Compare Current Setting with Default Setting* permits comparing RAM and EEPROM values for either the *current parameter type* or for all parameters, depending on what you selected in the associated submenu. The concerned current setting values are displayed in red if they differ from the corresponding default setting value as in Fig. 49 .

- *Reset Current Setting to Default Setting* permits resetting the RAM values to the EEPROM values for all parameters.
- *Write Current Setting to Default Setting* permits writing the RAM values to the EEPROM for all parameters.

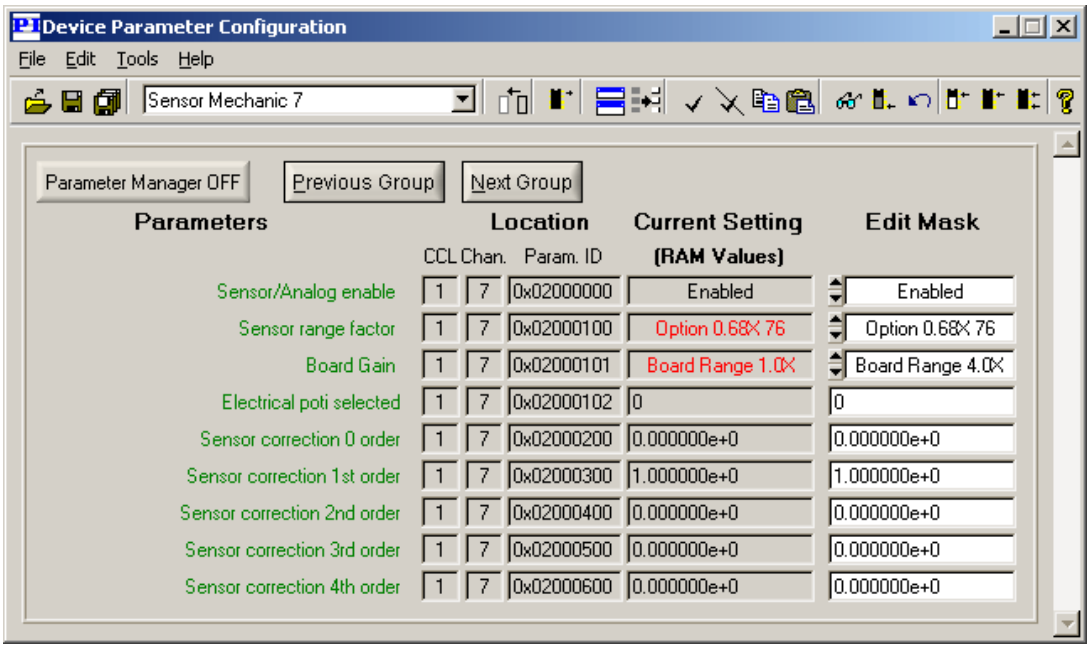


Fig. 49.Device Parameter Configuration window containing values that differ between current (RAM) and default setting (EEPROM).

10.3.1..4 Help

Fig. 50.

- *Device Info* pops up a window displaying the identification string obtained from the controller, including firmware version number.

11. Controllers and their Features—Overview

The appearance of *NanoCapture*™ in parts depends on the features of the controller used. Not all items are always available. The list below gives an overview over the available functions for the currently supported controllers.

Feature	E-710	E-761	E-755.1A1	E-755.101
Communication:				
RS-232	✓	-	✓	✓
Daisy chain	-	-	✓	✓
IEEE 488	✓	-	-	-
PCI bus	-	✓	-	-
Connected Axes Selection:	✓	✓	-	-
Axes Referencing:	-	-	✓	-
AutoFocus:	✓, only 6-ch versions	-	-	-
AutoZero:	✓	✓	-	-
Dynamic Tuner:	✓	✓	✓	-
Current Axis Action:				
Step Response	✓	✓	✓	- can be done in the Command Terminal
Frequency Response	✓	✓	✓	- can be done in the Command Terminal
Simple Waveform	✓	✓	-	-
Advanced Waveform	✓	✓	-	-
Record Table Report	-	✓	✓	✓
Graphic Report / Settings Field:				
Graph tab card	✓	✓	✓	✓
Graphs tab card	✓	✓	-	-
Settings tab card	✓	✓	-	-
Record Tables tab card	-	✓	✓	✓

12. Troubleshooting

12.1. Connection Failure

Make sure that no other program uses the interface.

E-710:

Check the cable connections. If using RS-232, make sure the included null-modem cable or equivalent is being used. Try to reconnect with different baud rates. Try closing and reopening the *Device Connection* window or restarting *NanoCapture*™. Try power-cycling the controller. Try resetting the controller baud rate to 9600 (this is usually done by switching the controller off before the power LED glows a steady green; see the controller User Manual) and connecting at that baud rate. If using IEEE 488 (GPIB) make sure the address setting are correct (usually 4).

E-761 only:

Press the *Reboot* button in the *Device Connection* window. Select the correct board number.

E-755 only:

Check the cable connections. Make sure the included null-modem cable or equivalent is being used. Try to reconnect with different baud rates. Try closing and reopening the *Device Connection* window or restarting *NanoCapture*™. Try power-cycling the controller.

If you use a daisy chain connection:

- The maximum number of devices in a daisy chain is 16.
- Interconnect all devices before you power them up.
- Do not connect a daisy chain cable to the CHAIN IN socket of an E-755 which is connected to the host PC via the RS-232 interface. Otherwise the internal synchronization of the E-755 will malfunction, and servo settings and move commands sent over the RS-232 interface will be ignored.
- The baud rate for the daisy chain connection can be set arbitrarily, but all devices in a chain must have the same baud rate.
- In the *Command Terminal* of *NanoCapture*™ always use the "normal" syntax and not the special syntax with TargetID and SenderID which is described in the controllers User Manual. The GCS DLL used by *NanoCapture*™ internally handles the TargetIDs and SenderIDs.

12.2. Passwords and CCL Level

Depending on the controller, changing some parameters and running some commands may require the command control level (CCL) 1 or 2. The command level can be changed either by entering and executing the CCL GCS command in the *Command Terminal*, or by entering a password in the dialog (Fig. 51) which pops up automatically when you try to change the value of a protected parameter in the *Device Parameter Configuration* window. Note the following:

- The availability of the CCL command depends on the controller firmware.
- Command level 2 is reserved for service personnel.
- The two different ways to change the command level require different passwords for level 1:
  The CCL entry in the *Command Terminal* (*Config → Command Terminal)*

requires the password “advanced”.
The *Nanocapture*™ password dialog box requires the password “E-710.3CD.4CL” or the CCL password itself (i.e. "advanced" for CCL 1).

- The password dialog will pop up and require input even if the appropriate command level was already set with CCL in the *Command Terminal*. It will not pop up any more, when the command level required by the parameter(s) was already set via the password dialog.
- Entering the password in the password dialog affects also the CCL setting.

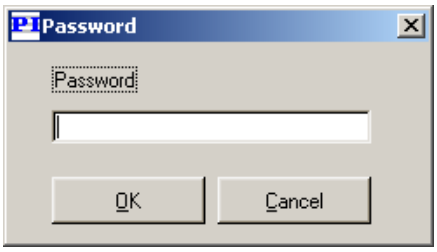


Fig. 51. Password dialog box which pops up when protected parameter values are changed in the Device Parameter Configuration *window (and some other windows)*

12.3. Keeping Optimized Parameter Settings

Note that for stages with ID-chip the option "Read ID-Chip always" must be disabled by default (parameter ID 0X0F000000, *System Mechanic n* parameter groups in the *Device Parameter Configuration* window). Otherwise any optimized settings that were saved to non-volatile memory will be overwritten by the ID-chip values every time the controller is powered up. See the controller User Manual for more information on the ID-chip functionality.

12.4. Error Messages

Some error messages may not appear until longer after the command that caused them was sent from the *Command Terminal*. When testing ASCII commands with the *Command Entry* field, it is a good idea to check for errors after each command.

E-710 only: If you use native commands (not recommended), keep in mind that the *ERR?* button may not “see” all errors from commands in the native ASCII command set, nor are all *ERR?* conditions cleared by successful native commands. This may also affect buttons which send commands to the controller, as they often check for error conditions and display any errors reported in a message window.

12.5. Position Offset—E-710 only

If a consistent offset between the commanded and the actual position is observed, with certain controllers (e.g. the E-710) the reason may be that the wave generator is outputting a constant non-zero contribution to the target. This can occur after running a waveform with a non-zero first point. The native MD command can be used to zero this offset. See the controller User Manual for details.