ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

LABORATORY FOR BIO AND
NANO INSTRUMENTATION

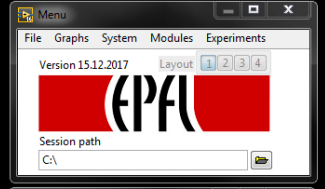
USER GUIDE

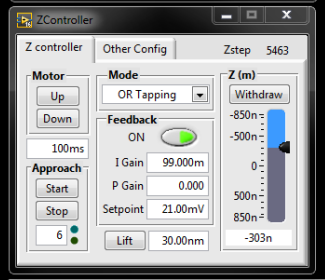
LBNI AFM Controller Software

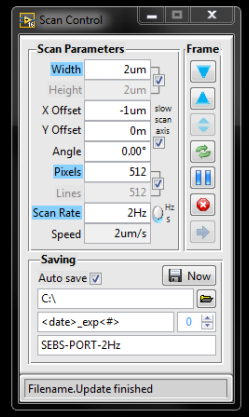
USB-7856R-OEM

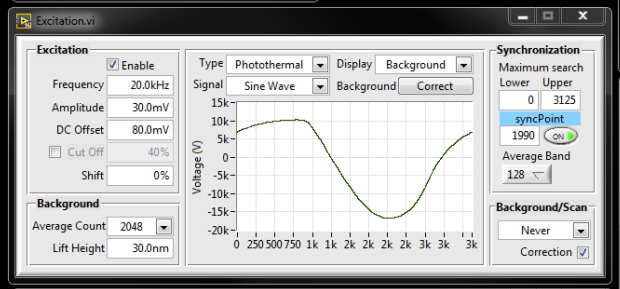
Charlène Brillard

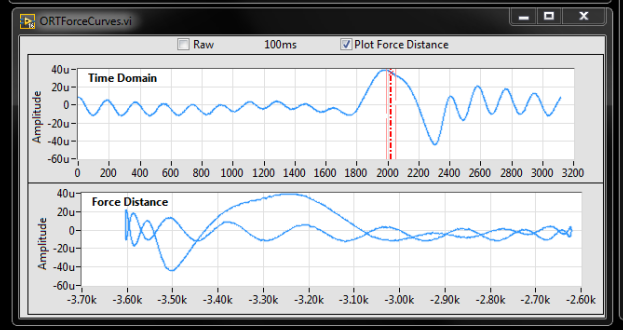
05.10.2018 – Beta Version 2.0.8

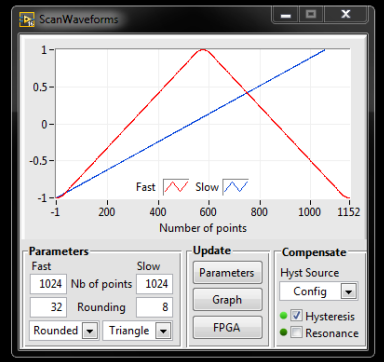

Menu
File Graphs System Modules Experiments
Version 15.12.2017
Session path
C:\

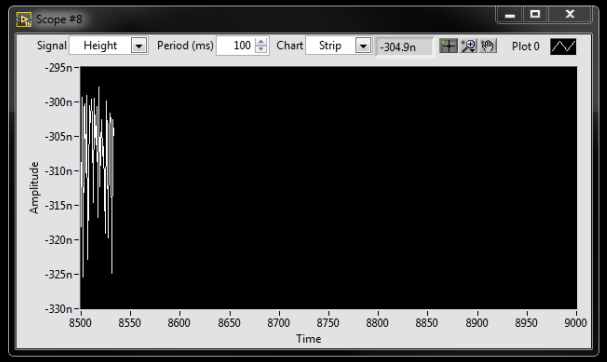

ZController
Z controller
Other Config
Zstep 5463
Motor
Up
Down
100ms
Approach
Start
Stop
Mode
OR Tapping
Feedback
ON
I Gain 99.000m
P Gain 0.000
Setpoint 21.00mV
Lift 30.00nm
Z (m)
Withdraw
-303n

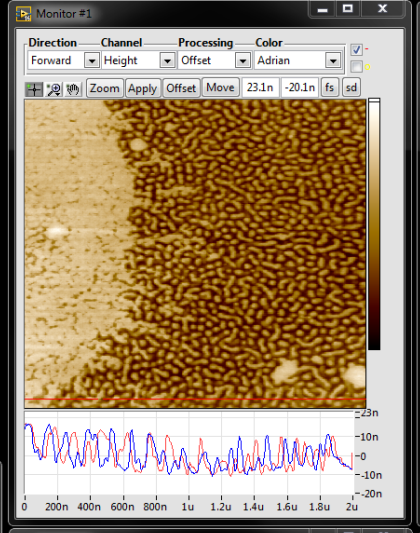

Scan Control
Scan Parameters
Width 2um
Height 2um
X Offset -1um
Y Offset 0m
Angle 0.00°
Pixels 512
Lines 512
Scan Rate 2Hz
Speed 2um/s
Frame
Saving
Auto save
Now
C:\
<date>_exp<#>
SEBS-PORT-2Hz
Filename.Update finished

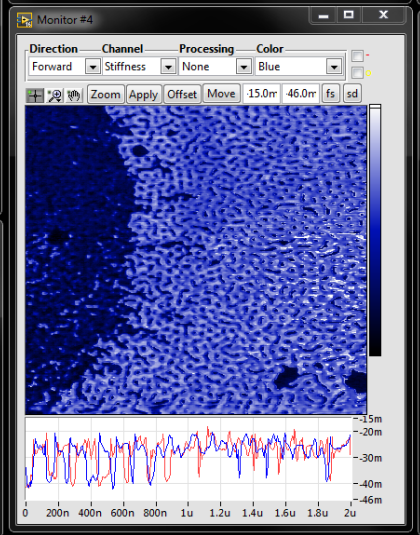

Excitation.vi
Excitation
Enable
Frequency 20.0kHz
Amplitude 30.0mV
DC Offset 80.0mV
Cut Off 40%
Shift 0%
Type Photothermal
Signal Sine Wave
Display Background
Background Correct
Synchronization
Maximum search
Lower Upper
0 3125
syncPoint
1990
Average Band
128
Background
Average Count 2048
Lift Height 30.0nm
Background/Scan
Never
Correction
Voltage (V)

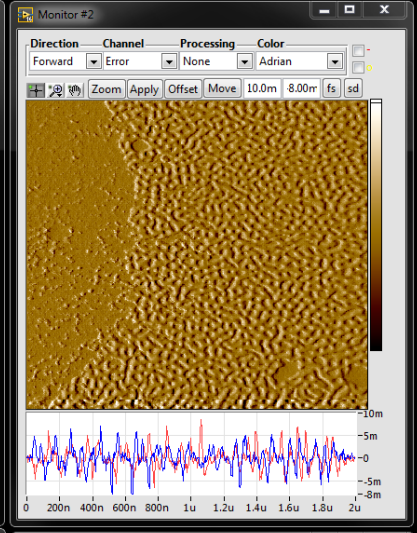

ORTForceCurves.vi
Raw
100ms
Plot Force Distance
Time Domain
Amplitude
Force Distance

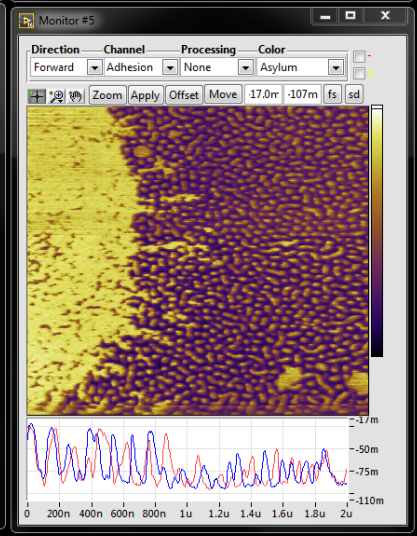

ScanWaveforms
Fast
Slow
Number of points
Parameters
Fast
Slow
1024
Nb of points
32
Rounding
8
Rounded
Triangle
Update
Parameters
Graph
FPGA
Compensate
Hyst Source
Config
Hysteresis
Resonance

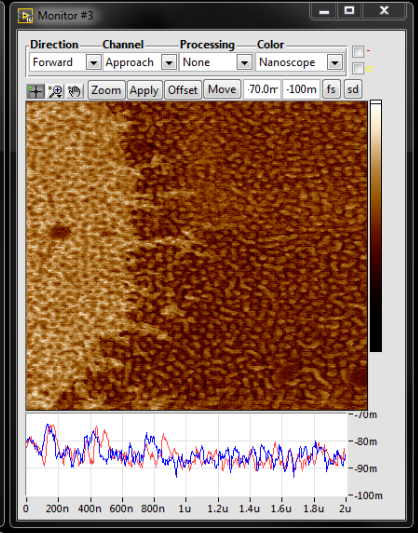

Scope #8
Signal Height
Period (ms) 100
Chart Strip
Plot 0
Amplitude
Time

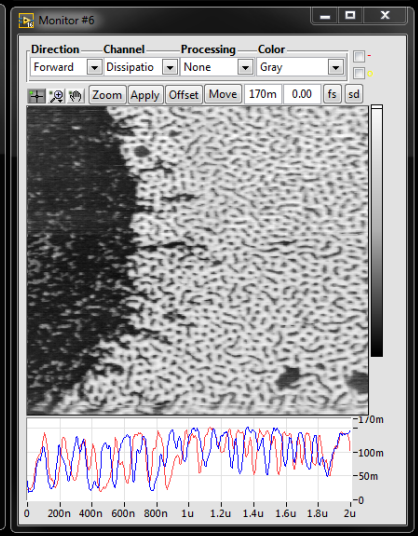

Monitor #1
Direction Channel Processing Color
Forward Height Offset Adrian
Zoom Apply Offset Move 23.1n -20.1n fs sd

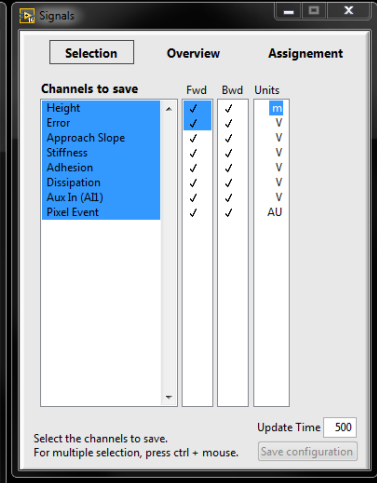

Monitor #4
Direction Channel Processing Color
Forward Stiffness None Blue
Zoom Apply Offset Move 15.0m 46.0m fs sd

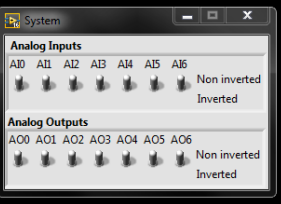

Monitor #2
Direction Channel Processing Color
Forward Error None Adrian
Zoom Apply Offset Move 10.0m -8.00m fs sd

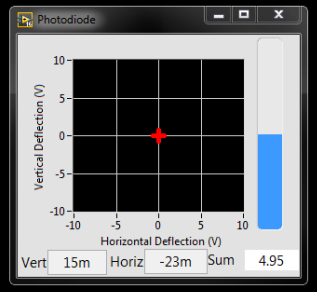

Monitor #5
Direction Channel Processing Color
Forward Adhesion None Asylum
Zoom Apply Offset Move -17.0m -107m fs sd

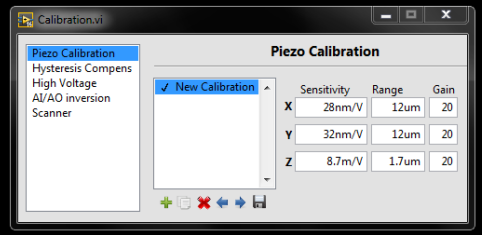

Monitor #3
Direction Channel Processing Color
Forward Approach None Nanoscope
Zoom Apply Offset Move -70.0m -100m fs sd

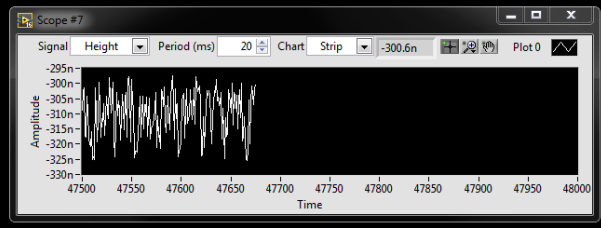

Monitor #6
Direction Channel Processing Color
Forward Dissipatio None Gray
Zoom Apply Offset Move 170m 0.00 fs sd

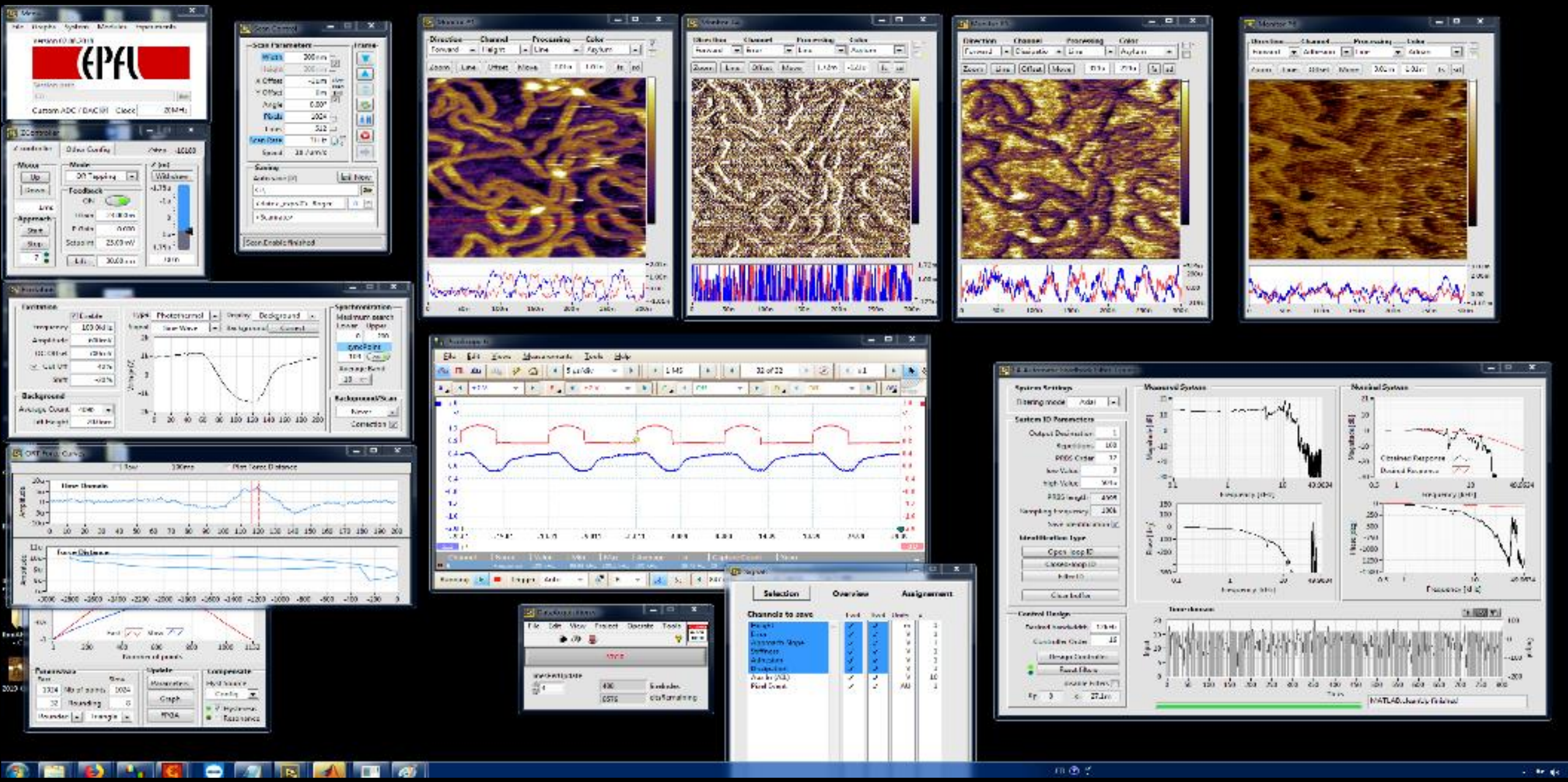

Signals
Selection
Overview
Assignement
Channels to save
Fwd
Bwd
Units
Height
Error
Approach Slope
Stiffness
Adhesion
Dissipation
Aux In (AI1)
Pixel Event
Update Time 500
Select the channels to save.
For multiple selection, press ctrl + mouse.
Save configuration


System
Analog Inputs
AI0 AI1 AI2 AI3 AI4 AI5 AI6
Non inverted
Inverted
Analog Outputs
AO0 AO1 AO2 AO3 AO4 AO5 AO6
Non inverted
Inverted


Photodiode
Vertical Deflection (V)
Horizontal Deflection (V)
Vert 15m
Horiz -23m
Sum 4.95


Calibration.vi
Piezo Calibration
Hysteresis Compens
High Voltage
AI/AO inversion
Scanner
Piezo Calibration
New Calibration
Sensitivity
Range
Gain
X 28nm/V 12um 20
Y 32nm/V 12um 20
Z 8.7nm/V 1.7um 20


Scope #7
Signal Height
Period (ms) 20
Chart Strip
Plot 0
Amplitude
Time



This Guide is a beta version

Not finished

Will be improved soon

For any question, contact me at familynamefirstname@gmail.com

ENVIRONMENT: LabVIEW 32bits

The Code has been developped with Labview 2016 (32 bits).

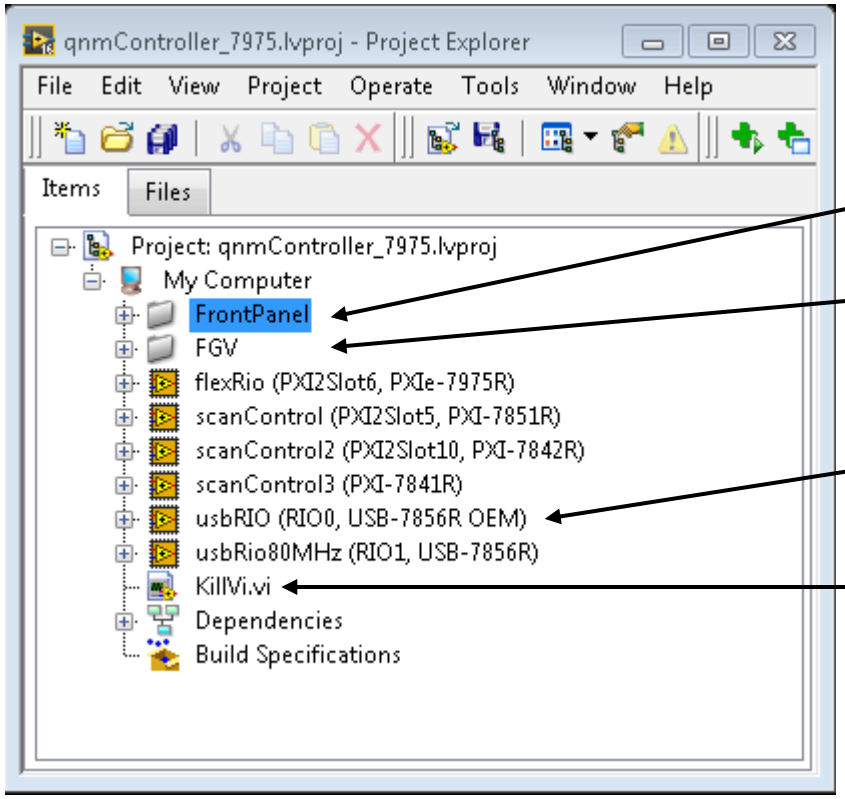
The Code can run on several targets

USB-7856R OEM USB-7856R	Full code
PXIe-7975R	Feedback
PXI-7851R PXI-7841R	Scan

But the easiest to interface is the USB-7856R OEM

When debugging, check your signals with an external oscilloscope

Open the Projet LBNIController.lvproj



The software with his modules.
Menu.vi is the VI to run at first and will offer an interface to open the other modules.

Functional Global Variable.
If you want to change parameters at the initialization like the Calibration.

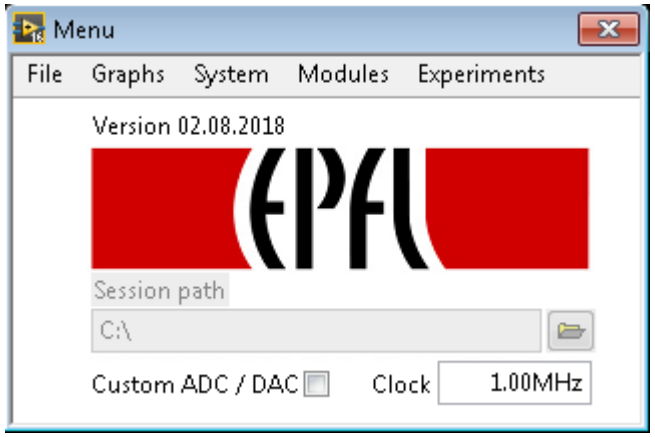
The target with the FPGA Code
A bitfile containing the FPGA Code optimization is loaded on the target by the host.

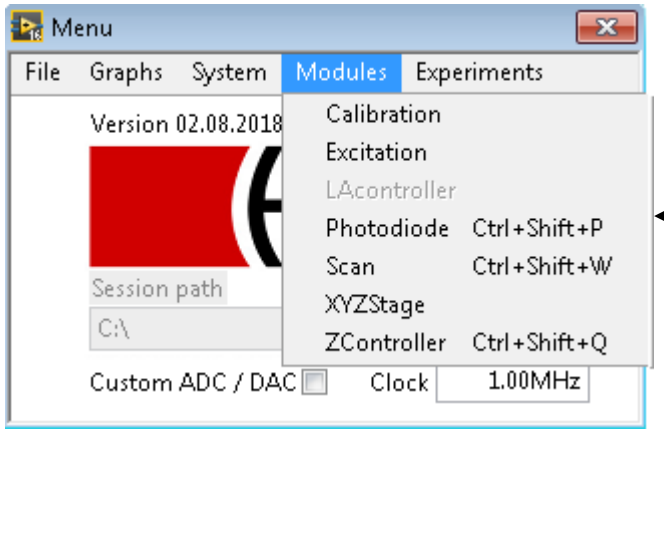
When a VI is locked: replace the name of the VI and run

Host: the top-level code on the computer
FPGA: The low-level code on Limited Physical Resource for Real-Time operations

MENU

From the project, open FrontPanel\Menu.vi and run the vi.

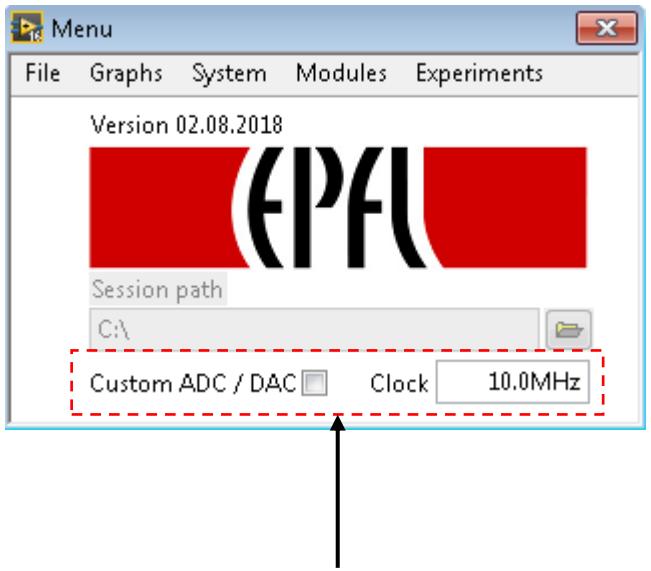




Navigate through the menu to select the modules you want to work with

Click on your choices, the modules windows will be opened

MENU – 10 MHz DAC/ADC



Change the clock signal value and switch from the Analog Input/Output to Custom ADC/DAC
To get a higher Sampling Rate for the Feedback and Excitation Signals

Available when then is a DAC/ADC attached to the respective DIO lines.

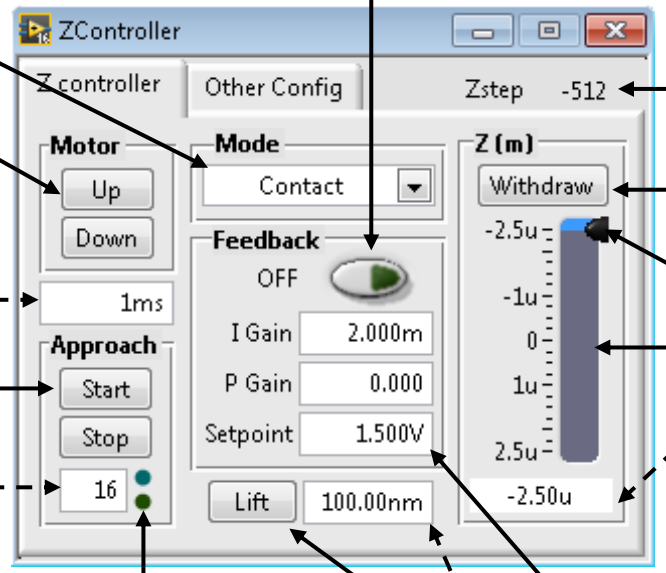
ZCONTROLLER

In the Submenu « Modules »

Feedback modes
- Contact
- Off-Resonance Tapping
- Auxiliary: user configurable

Enable the PID/ Disable the PID = enabling the manual motion

/!\ Disabling the PID doesn't retract the piezo. It freezes the position or enable to manually change the Z piezo position /!



Press on these buttons to move the motor up / down
The longer you press, the most steps

Time between two steps : 1ms is standard (min)
It makes sense to change it if you want to change the position of the piezo or approach manually

Start/Stop the Auto-Approach to find the surface

Number of steps done by the stepper motor during the auto-approach between two enabling/disabling of the Feedback. Multimode: 1 step = 200-300nm

Number of steps moved by the Stepper motor

Fully retracts the piezo.
Press 4s and the stepper motor will move of the number of steps in «Approach»

PID on: Indicates the position of the Z piezo
PID off: Control the position of the Z piezo

Dragging the black cursor in the blue bar, clicking in the bar, or replacing the digital indicator by the requested value move manually the Z piezo to the requested position at a speed set in «Other Config»

To set the speed of the auto-approach, **change the I Gain** and/or the setpoint.

Blue led: Auto-Approach is running
Green led: Surface found

Set the parameters of the PI Controller and the setpoint in V

Move the tip up relative to the current position by the Lift height

Tip: Before starting the auto-approach, check how fast the piezo extends with the current gain and setpoint by enabling the feedback, for a soft approach

ZCONTROLLER

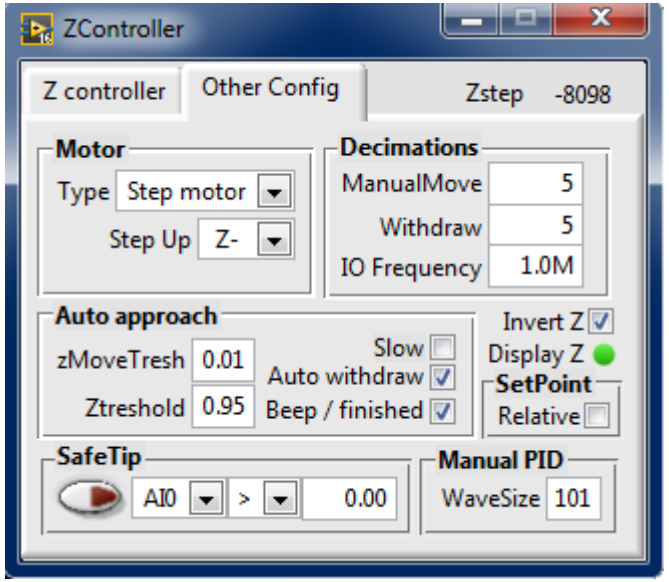
- Other config

Select the type of system used to approach the tip and the sample. The left panel of Z Controller will adapt depending on the needed parameters

- Stepper Motor (Multimode : A, B, C, D digital signals)
- DC Motor
- Stepper Motor Driver (Enable, Direction, Steps)
- Stick-Slip stage (+ open the complementary module)

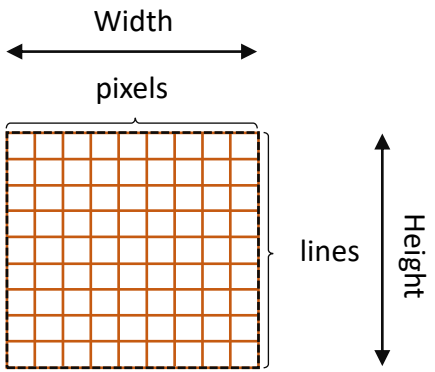
Set the direction for the up/down motor movement
(the config by default is pretty standard)

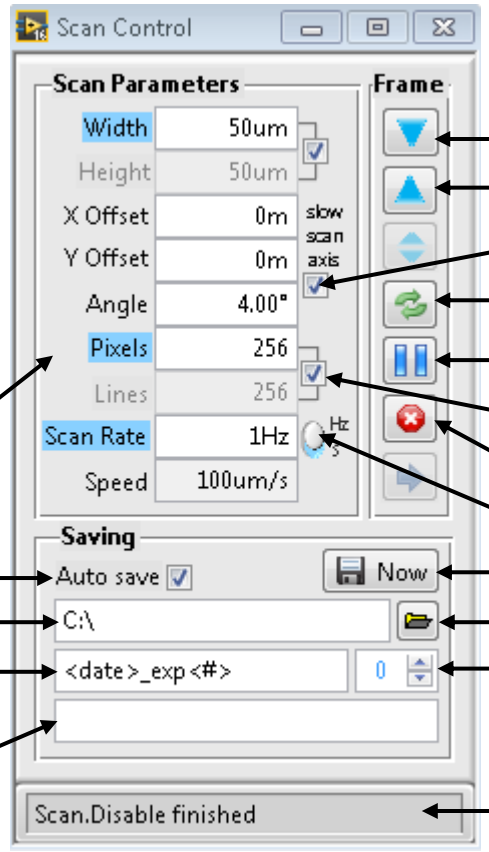
Auto-Approach configuration:
- Do you want a beep sound when the surfaces is found
- Do you want to stay landed on the surface or withdrawn
- Do you want to hack the auto-approach (slow)



Relative enable: Engage on a percent decrease of the setpoint (useful for drifty signals, can find application for tapping mode)

SCAN





Changing the pixel/line restarts the scan from zero

If activated, save the picture at the end of each scan

Base Folder name (should be an existing path) and finish by \

Create a folder for the experiment at every name update.

Placeholders <date>_exp<#> can be removed or completed

An empty filename is replaced by the date and time + the number of the picture of the day « 000x » + added text + .gwy

Frame down (at every beginning of image)

Frame up (at every beginning of image)

Scan the same line in case of false and make a picture of it

Alternate the direction of the scan

Pause the scan at the current tip position.
To continue the scan, press Pause again.

Lock the value to the same of the top one

Stop the scan and move the tip to zero position

Change the speed display parameter from Hz to s(/line)

Save the current picture (refering to what is displayed in the monitor)

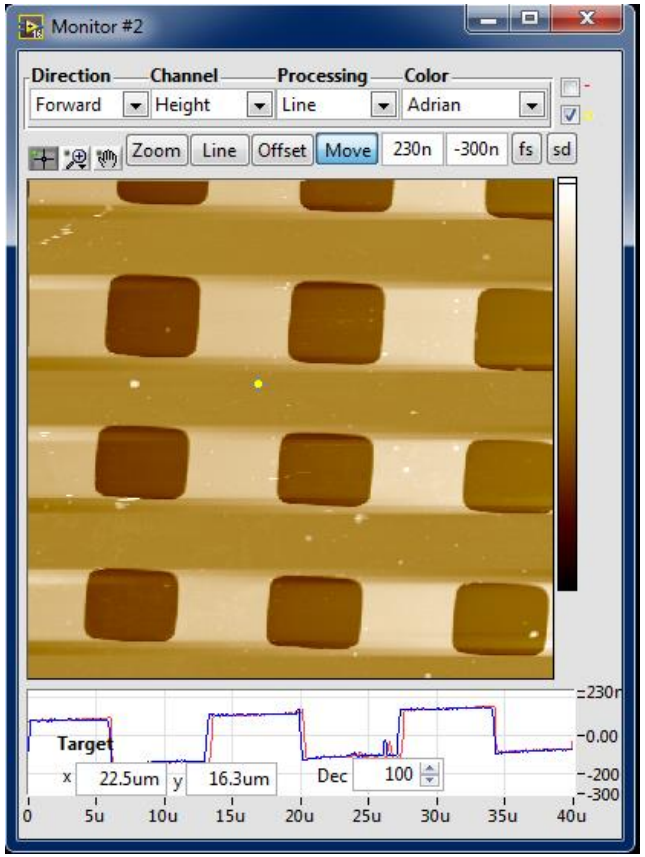
Browse the Folder

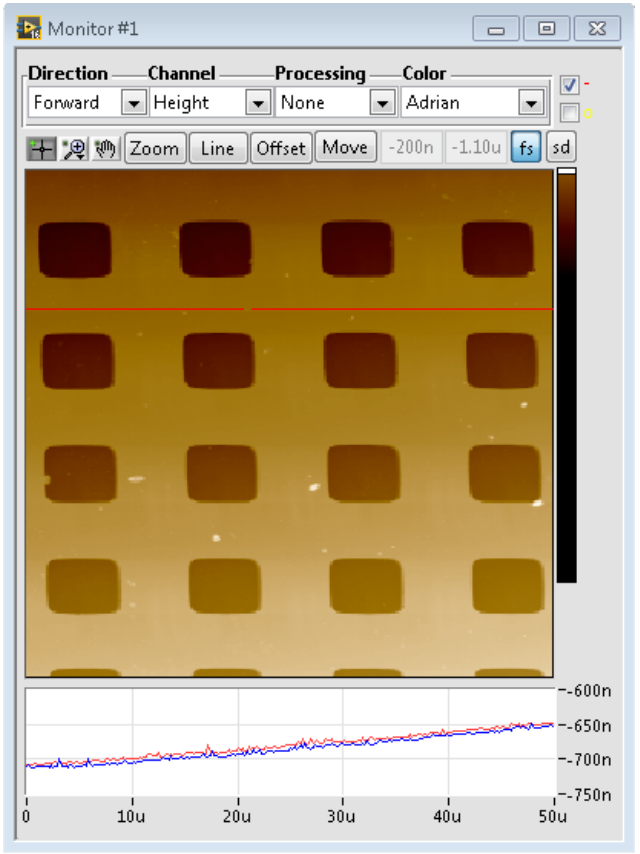
of the experiment (replace the placeholder)

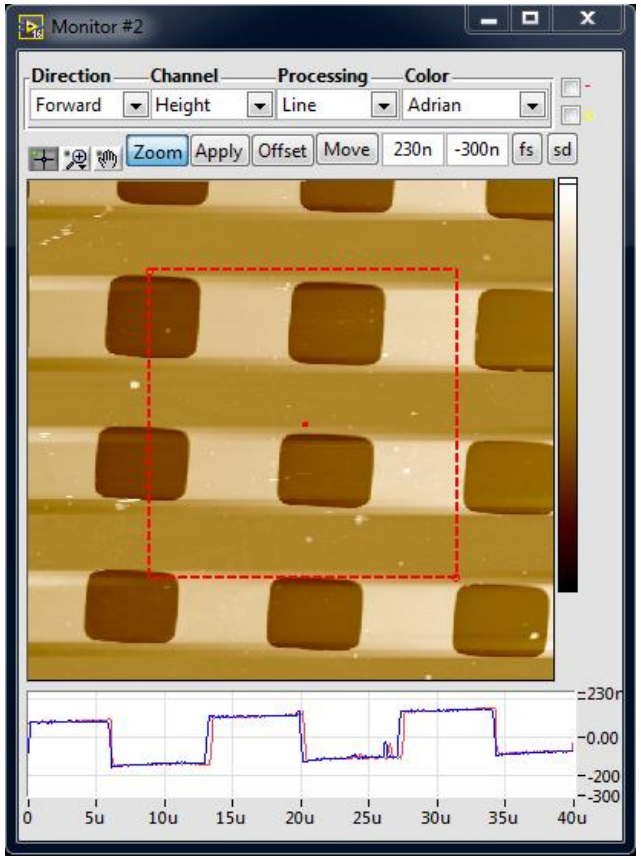
Tells you what's happening, it is busy when not written « …finished »

MONITOR

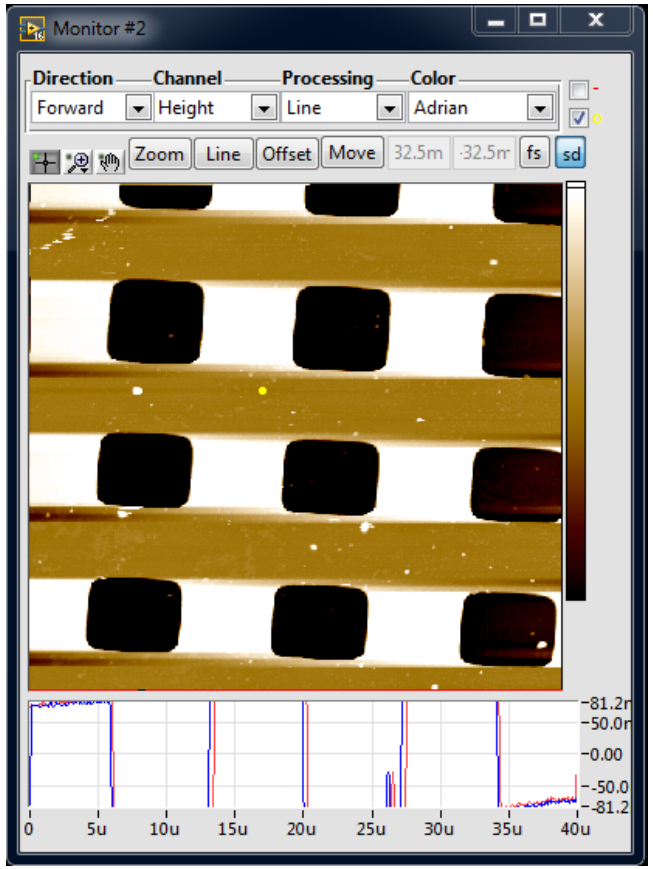
Open as many as needed from «Graphs» by clicking several times on «Monitor»

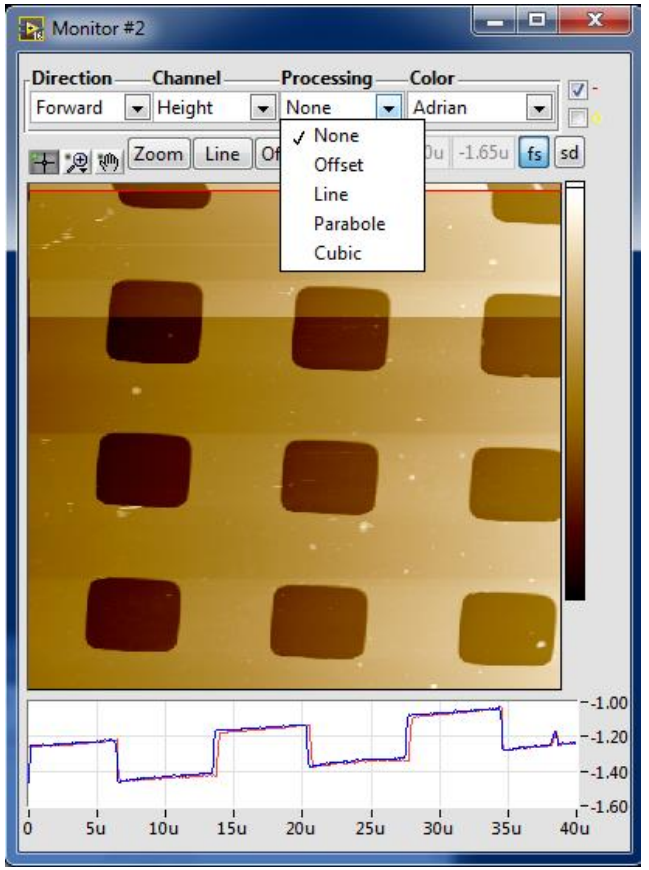




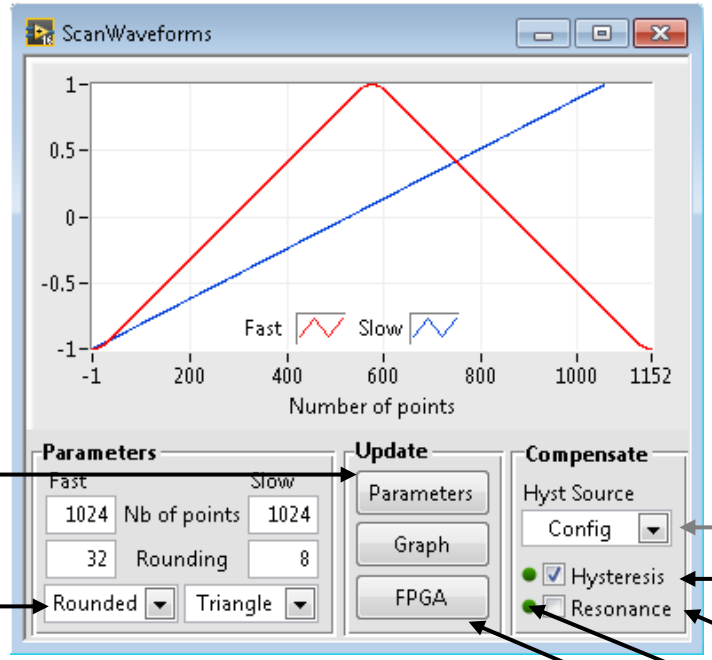


MONITOR


Monitor #2
Direction
Channel
Processing
Color
Forward
Height
Line
Adrian
Zoom
Line
Offset
Move
32.5m
32.5m
fs
sd
-81.2n
-50.0n
-0.00
-50.0
-81.2
0
5u
10u
15u
20u
25u
30u
35u
40u


Monitor #2
Direction
Channel
Processing
Color
Forward
Height
None
Adrian
Zoom
Line
fs
sd
-1.65u
None
Offset
Line
Parabole
Cubic
-1.00
-1.20
-1.40
-1.60
0
5u
10u
15u
20u
25u
30u
35u
40u

MONITOR



Update the graph with the current parameters

«Rounded» triangle is the default choice for the fast axis. An abrupt change of direction in the scan (triangular waveform) creates ripples particularly visible at high scan speed. Rounding helps to reach higher speeds.

To ignore for the current development

Displays the waveform with the hysteresis correction on top

Apply the lateral resonance compensation from the filter

Indicate if the loaded waveform contains the correction

Send the waveform displayed in the graph to the FPGA

Generate 3 types of waveforms

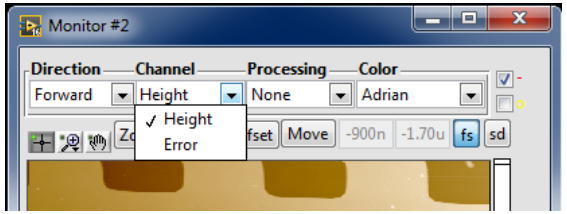
Triangle Rounded Triangle Sinus

Tip: The higher the scan speed, the more rounding is needed to avoid the ripples. Rounding also reduces the scan range as the voltage ramp applied to the piezo is modified.

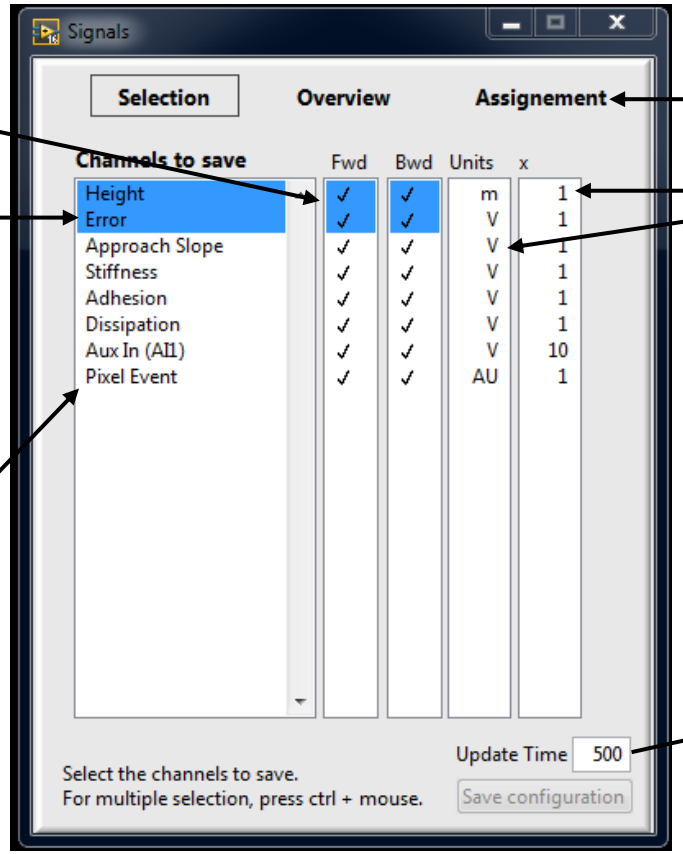
SIGNALS

Ctrl+click to select the channels to save (Forward and/or backward)

Ctrl+click to select channels to display
Resets the channels to save



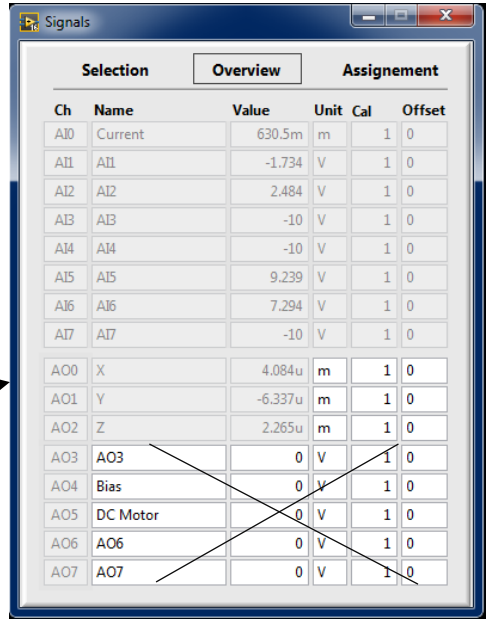
Change the text by clicking once in a line



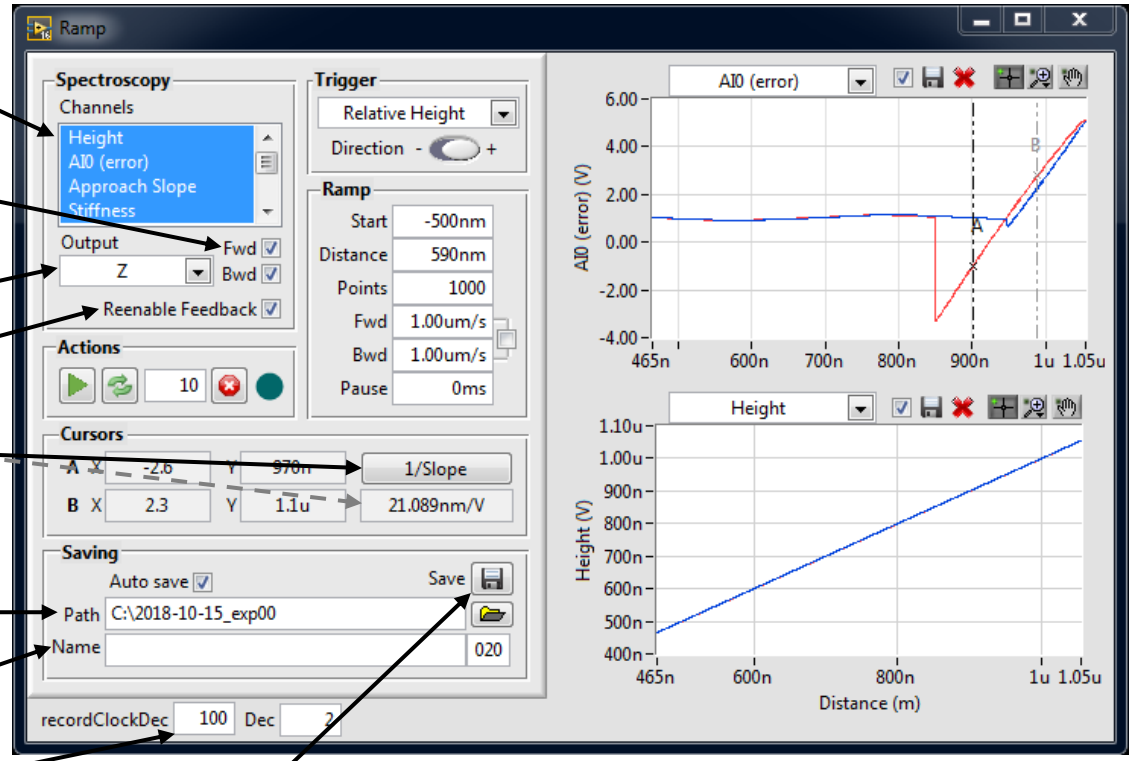
Choice of window panel: Selection/Overview/Assignement

Change the unit and calibration of the displayed and saved data

In **Overview**, monitor some signals (under development)



RAMP



Ctrl+click to select channels to display and save

There will always be a Backward
Can enable and disable the Forward movment for Pull

Choose the channel to ramp: Z
(Provision for Bias ramp for example)

Reenable the feedback after the ramp

Calculate the deflection sensitivity (in nm/V) by calculating the slope between A and B cursors on the error channel

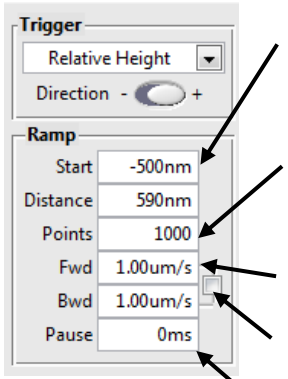
Has to be an existing path (Read from the path updated from Scan.vi)

If empty, replaced by Ramp_date_ x.txt

To play with bigger number of points, reduce the recordClockDec (careful with labview memory, not optimitized yet)

Save the current displayed force curved

Absolute Height: read positions from piezo
Process Variable: signal used for the feedback (deflection setpoint for example)
External: not tested yet
Relative height: start = the distance withdrawn from current position. distance = the ramp distance (from start)



- = from the surface
+ = towards the surface

Number of points
If red, too high for the record clock (advices given in context help)

Speed of Fwd movement

Lock the Bwd to Fwd speed

Delay after feedback is reenabled (useful for several ramps)

Start Ramping with the current parameters

Not useful for now

Number of ramps which will be done

Stops the ramp

Ramping state

Blue = Forward \\ Red = Backward (Sensitivity calibration: 1/slope)

EXCITATION

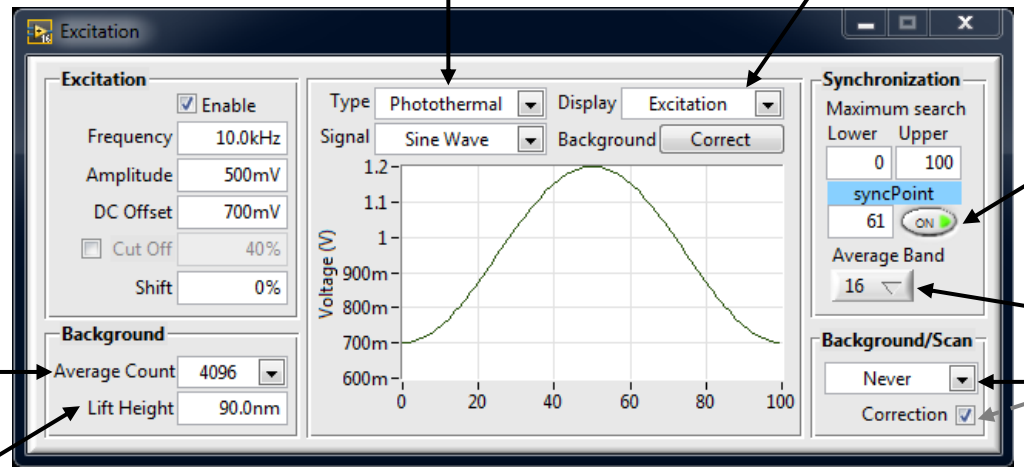
Changing the Frequency, the amplitude, the DC Offset (disables the excitation, withdraws the cantilever) loads the new parameter (and reenables the excitation and the Feedback). The Enable thick-mark is changing of status and text during this process.

ORT
PORT

Piezo : Signal added to the Z available in channel AO2. For example: AO2 = Z + Amplitude x sin(Ft) + DC Offset

Photothermal: Signal sent to the Drive in channel AO3. AO3 = Amplitude x sin(Ft) + DC Offset

Choice between displaying the Excitation signal or the Hydrodynamic Background after Correction



Sync point is where on the interaction curve the feedback is done.

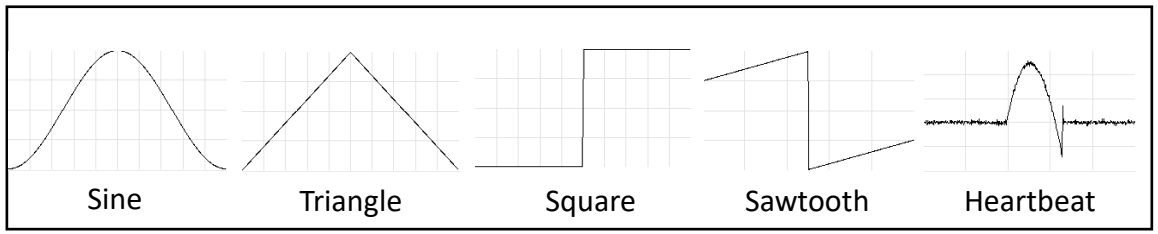
Before engaging, the *SyncPoint* has to be on and set to a sensicle value, from the background shape (automatically set at the minimum in case of PORT, can be refined. In case of ORT, guessed from experience.)

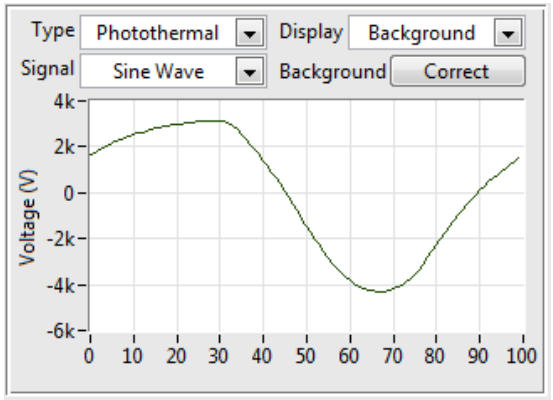
Average width around the *SyncPoint* in points where the feedback is done.

Correct the background at every *end of frame*, *end of line* or *never*.

Number of background curves taken to calculate the background and substract it to the feedback signal. The higher, the longer it takes to calculate

Distance withdrawn from the surface on correcting background





EXCITATION

Photothermal

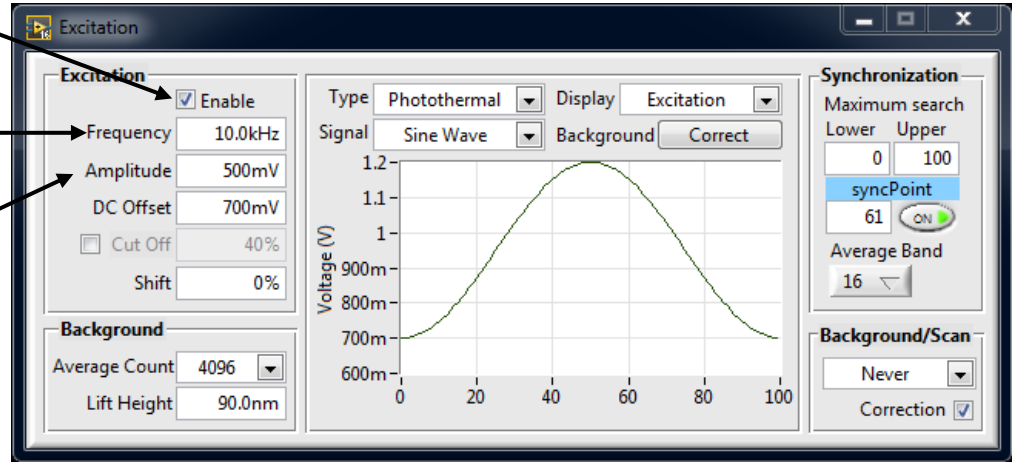
Enable the excitation in the drive channel (AO3)

Frequency of the signal

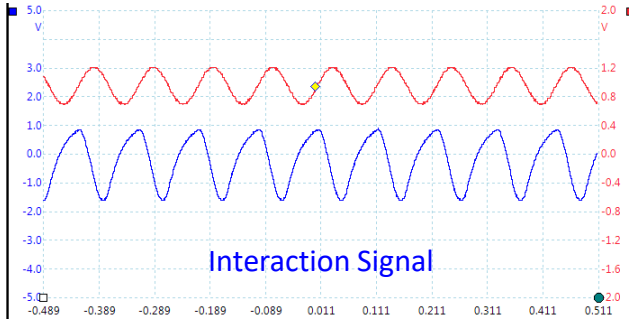
The value entered is coerced to the value really applied

Limited by the sampling rate of the analogs channels of the FPGA: With 1MS/s, F=30kHz ⇒ 33 datapoints

Frequency of the signal

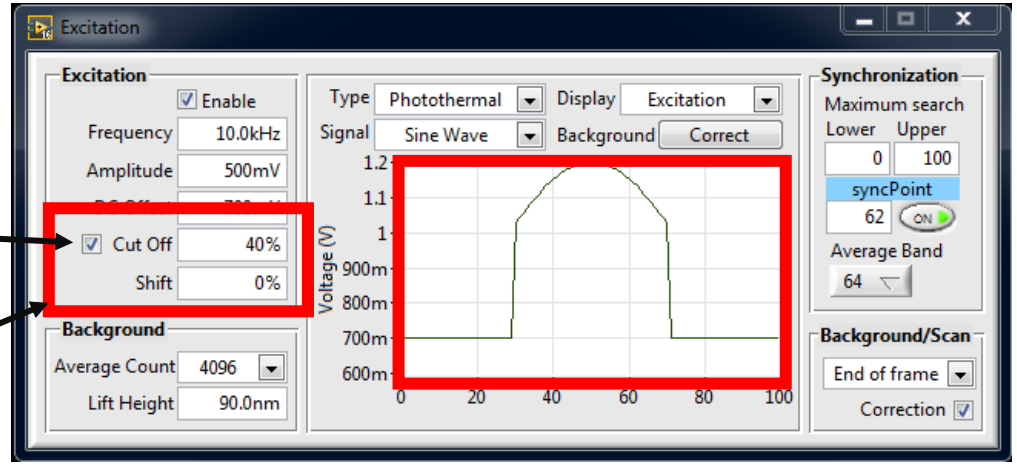


Excitation Signal



Cuts of the excitation by a certain pourcentage to reduce the duration of the pulse, particularly useful when exciting the cantilever thermally or photothermally)

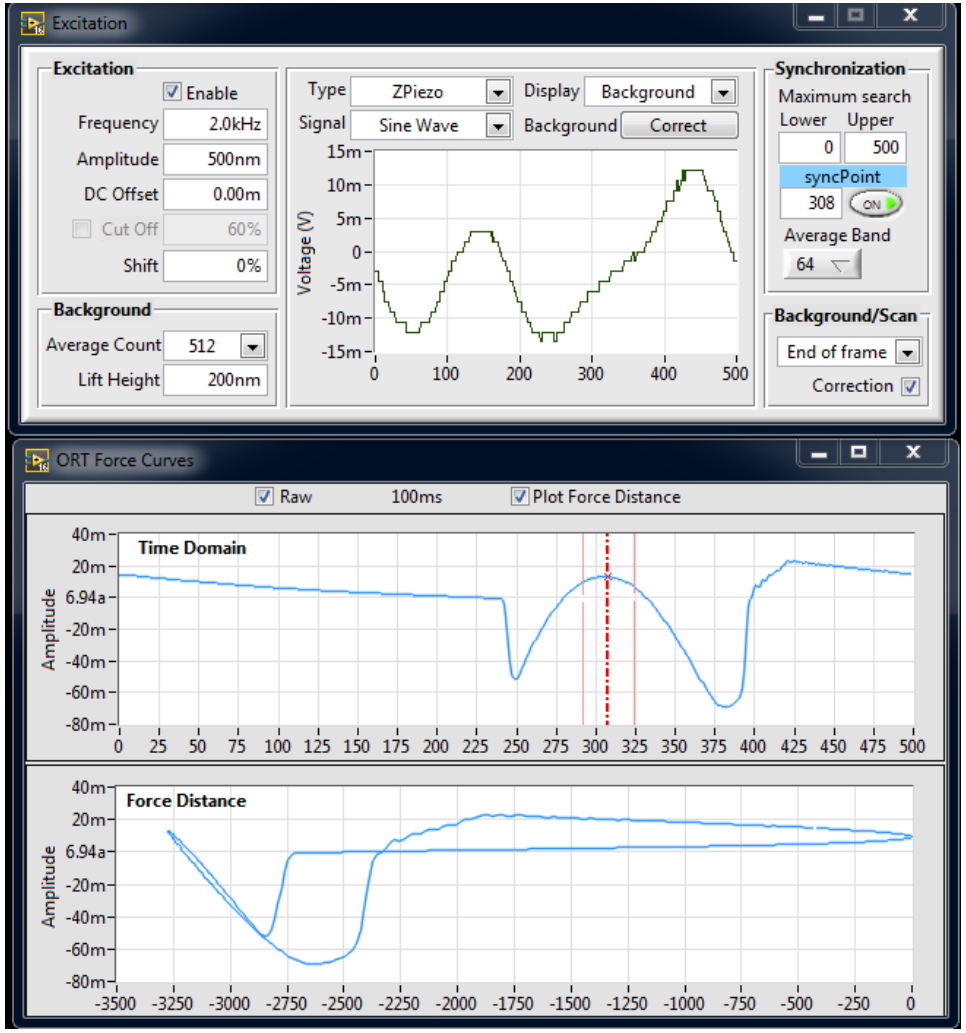
Shits the excitation pulse in the memory for visualisation of the interaction curve

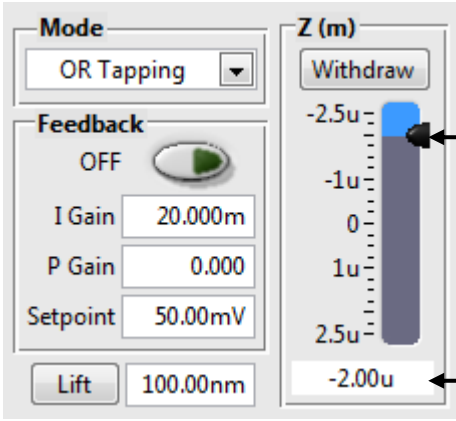


1 tap per pixel is the extreme minimum for the feedback. The Higher the Frequency, the faster you can scan. The Frequency can be increased depending on the cantilever: a Fast Scan D limit is

EXCITATION

Height

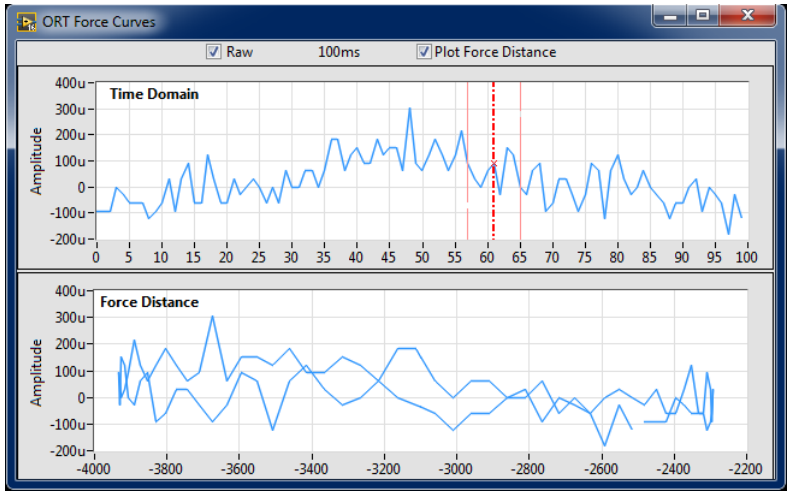


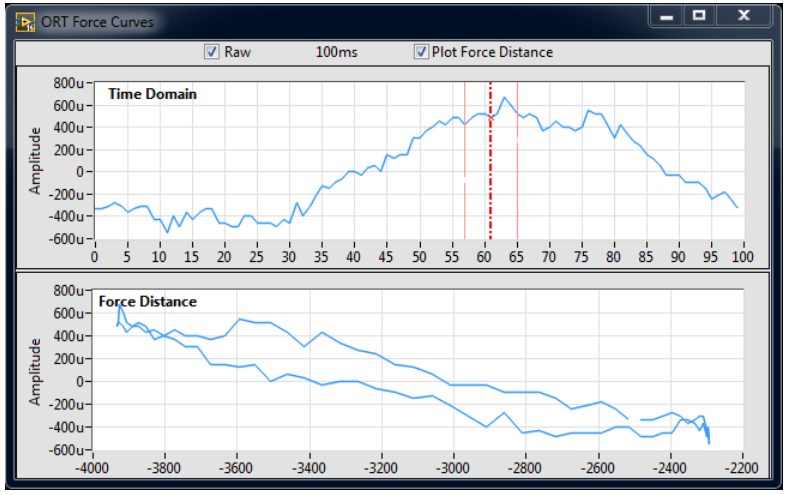


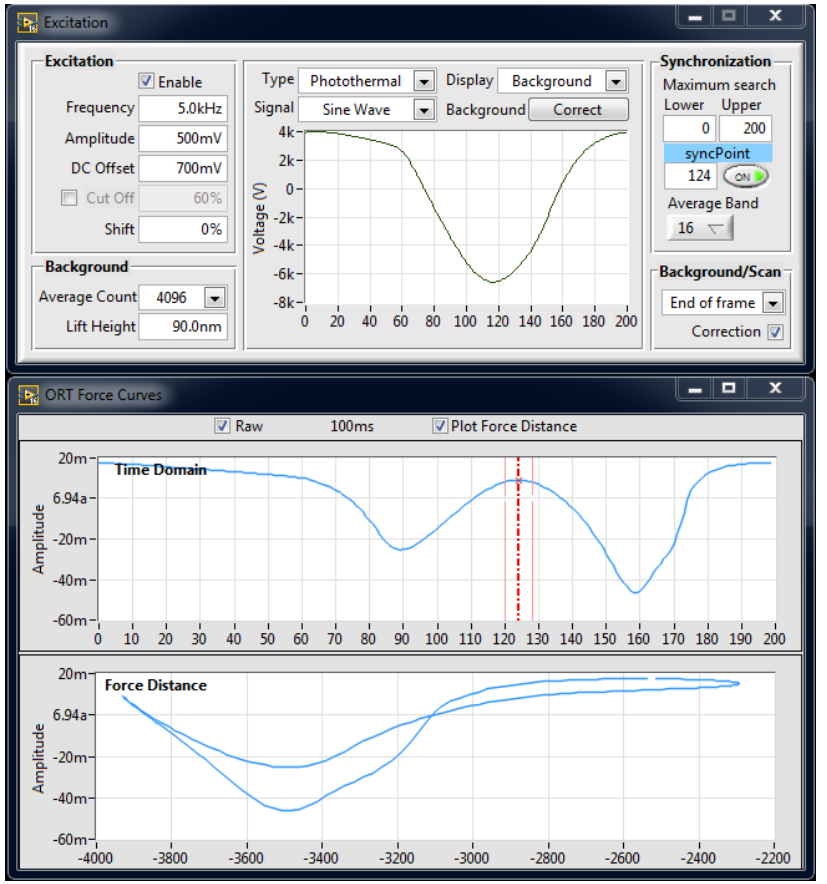
Normal limits of the piezo :
Lower = -Piezo range / 2 (-2.5um here)
Upper = +Piezo range / 2 (+2.5um here)

To avoid clipping and damaging the piezo,
Limits are defined in ORT:
Lower = -Piezo range / 2 + ORT Amplitude
Upper = +Piezo range / 2 - ORT Amplitude

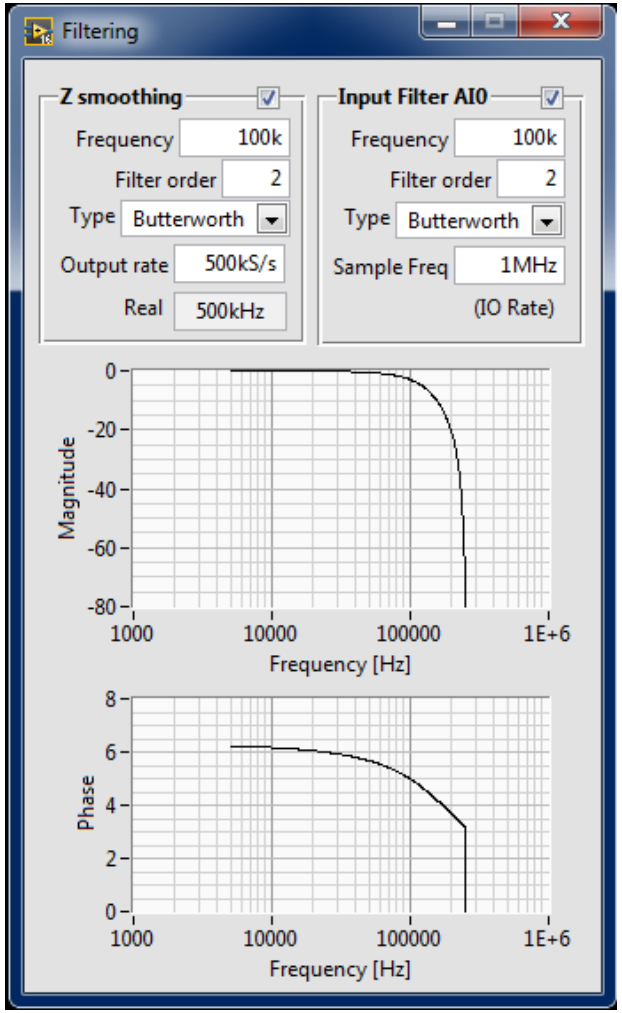
ORT FORCE CURVES







Filtering


Filtering
Z smoothing
Frequency 100k
Filter order 2
Type Butterworth
Output rate 500kS/s
Real 500kHz
Input Filter AI0
Frequency 100k
Filter order 2
Type Butterworth
Sample Freq 1MHz
(IO Rate)
Magnitude
0
-20
-40
-60
-80
1000
10000
100000
1E+6
Frequency [Hz]
Phase
8
6
4
2
0
1000
10000
100000
1E+6
Frequency [Hz]

OSCILLOSCOPE