

# NYU NANOLAB GUI VERSION3.0 MANUAL

**Preface:** This is the manual for the NYU NanaLab GUI (Version3.0). This GUI can be used to control the FPGA, pretreatment and real measurement as well as the data analysis. This manual will document how to use all of the possible features of the GUI and discuss some potential useful features for future development.

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## **1. Getting Started**

### **1.a Download appropriate software and prepare for functionable hardware:**

This GUI is developed under the MATLAB 2017b. Before you run this GUI, please make sure check your MATLAB version and this GUI guarantees to work properly under the MATLAB 2017b. If you are using any older MATLAB version, it is possible you will encounter some syntax errors. Please check those errors carefully (if you insist using older version but they are not hard to solve). As for the functionable hardware, you should prepare an useable main board containing useable FPGA with USB 3.0 and a four-channel chip.

A functionable NI-DAQ is also needed to generate the input signals as well as a faraday cages with at least 100dB noise cancelation during the pretreatment and the real measurement.

Once you prepare for all listed before, you will be able to run the GUI.

### **1.b Download all necessary GUI files and the usable bit file:**

Once you download the suitable MATLAB and finish all troubleshooting for hardware devices, you might download all necessary GUI files and the usable bit file on the link:

[https://github.com/NabiWu/NYU\\_NanoLab\\_GUI](https://github.com/NabiWu/NYU_NanoLab_GUI)

Open the Final GUI (Everything Needed) folder, download all files and place them into a local directory. Open the Firmware folder, download the bit file and place it to the same directory. It is possible this bit file doesn't adapt, please also view those Verilog files in the Firmware folder for your own troubleshooting as well as the online sources.

### **1.c Running the GUI:**

Once you download all needed file and have a usable bit file to control your FPGA (make sure they are all in same folder), open the newDC\_Decimation2.m file and click run to open the GUI. Then you will see the GUI window pops up. You are ready to use it.

## 1.d GUI layout introduction

The main GUI layout is shown below:

The GUI is organized into three main vertical panels:

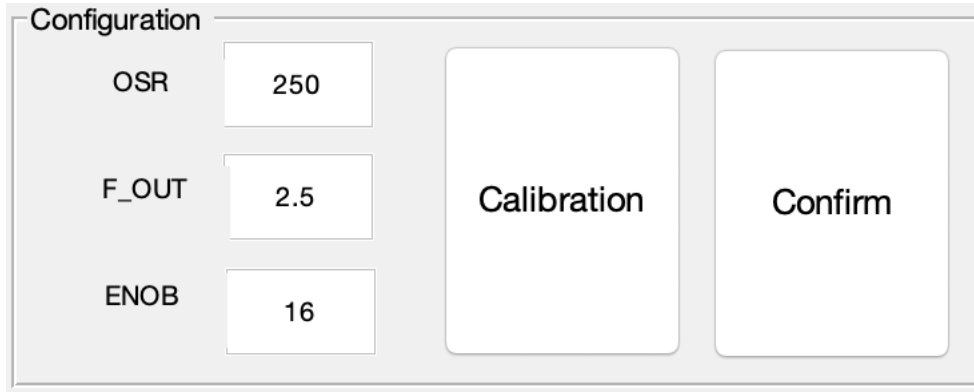
- Setup Panel:**
  - Configuration:** OSR (250), F\_OUT (2.5), ENOB (16). Buttons: Calibration, Confirm.
  - Chip Setup:** Enable, Unload, Reset. Channel1-4 with Enable/Disable, Measure, and PGA(dB) settings.
  - Input Signal Setup:** Ch1-4 Input Signal with PeakVol (1.3), BottomVol (-0.4), and Voom (0) settings.
- Experiment Running Panel:**
  - Pretreatment:** Frequency (Hz) 10, ScanRate (V/s) 200.
  - FSCV Setup:** Channels 1-4 with V (V) and I (V) ranges.
  - Precursor:** Channels 1-4 with V1, V2, V3, V4 and I1, I2, I3, I4 settings.
  - Cursor:** Channels 1-4 with V1, V2, V3, V4 and I1, I2, I3, I4 settings.
  - Pretreatment Analysis:** CH1 selected, Slope of I1-I4.
  - Save File:** Device ID (CM\_NSA\_57\_C1), File Name.
  - Duration (min):** 60, Start, Stop, Save Data.
- Data Analysis Panel:**
  - Pretreatment:** Current, Slope.
  - Measurement:** Ramp Signal, DA Cycles (570 to 590), Channel1-4.
  - NShape:** PBS Cycles start (80), DA Cycles start (400), Channel1 & 2, Channel3 & 4.
  - Machine Learning:**

The layout can be viewed as three parts: Setup, Experiment Running, and Data Analysis. The left most section is the Setup section. You can configure the FPGA, setup Chip as well as input signal. This manual will contain more detailed information in section 2. The middle section is the Experimental Running section which contains both pretreatment and real measurement section. For more detailed information, please view section 3 in this manual. The right most section is the Data Analysis. Please take a look at section 4 for more information.

## 2. Measurement Setup

### 2.a FPGA configuration and multi-tab plots generation

In the first part of the setup section which you will see as below:



The image shows a software interface for FPGA configuration. It is titled "Configuration" and contains three input fields on the left for parameters: "OSR" with a value of "250", "F\_OUT" with a value of "2.5", and "ENOB" with a value of "16". To the right of these fields are two large, light-colored buttons labeled "Calibration" and "Confirm".

The OSR, F\_OUT and ENOB are three parameter corresponds to what type of FPGA you use. Please make sure you have the corrects value before you start any measurement. The calibration button stands for calibrating the p\_left and p\_right values for your chip after you click the calibration button, you will automatically calibrate those p values for further measurements. The confirm button will allow you to confirm the configuration with your FPGA as well as generate the multi-tab plot window which contains four different tabs corresponds to real-time plots for each four channel. \*Please leave that window open, all the real-time visualization will display on this window.

## 2.b Chip setup

The following figure shows the Chip setup section:

The screenshot displays a 'Chip Setup' window. At the top, there are three buttons: 'Enable', 'Unload', and 'Reset'. Below these, there are four channel configuration panels arranged in a 2x2 grid. Each panel is titled 'Channel1', 'Channel2', 'Channel3', and 'Channel4' respectively. Each panel contains an 'Enable' radio button, a 'Measure:' dropdown menu, and a 'PGA(dB):' dropdown menu. The 'Measure:' and 'PGA(dB):' dropdowns are currently set to 'V' and '0dB' respectively. The 'Enable' radio buttons are currently unchecked.

Before you decide to use which channel for measurement, please click Enable button at first. Enable button will allow you to set up the wire in value based on your choice. The Unload button will disable the FPGA, while you want to exit the GUI, please make sure you click the unload button at first. If you click the unload button by chance, you need to close the plot window first and reconfigure the FPGA in the second step. The Reset button will set every wire in value to 0. As usual, you need to click the Enable button first and click the Reset button for further chip setup.

After you enable the FPGA, you can now enable each channel and chose the PGA(dB) value you prefer. The GUI provide four types of PGA(dB) values: -3dB, 0dB, 6dB, 12dB. For channel 2&4, you can choose either voltage or current you want to measure.

## 2.c Input signal setup

Once you finished the Chip setup, you might want to setup the Input signal as below:

Ch1 Input Signal		Ch2 Input Signal	
PeakVol (V)	1.3	PeakVol (V)	1.3
BottomVol (V)	-0.4	BottomVol (V)	-0.4
Vcom (V)	0	Vcom (V)	0

Ch3 Input Signal		Ch4 Input Signal	
PeakVol (V)	1.3	PeakVol (V)	1.3
BottomVol (V)	-0.4	BottomVol (V)	-0.4
Vcom (V)	0	Vcom (V)	0

You can set the peak voltage, bottom voltage and vcom for all four different channels. However, GUI version 3.0 doesn't provide any functionality for generate ramp signal and control it on NI-DAQ. For future developer, if you are interested in using GUI to directly generate signal via NI-DAQ, I recommend you take a look at the new GUI version 2.0 in the same GitHub repo. I implemented the similar functionality on GUI 2.0 and it works fine except a delay proportional to how long the measurement takes. Since we need to use this GUI to pretreatment (usually for one hour), the delay will be significantly larger; therefore, I used separately program to generate the signal and control it on NI-DAQ. For more information, you can view this link:

[https://github.com/NabiWu/NYU\\_NanoLab\\_GUI/tree/main/Functionality](https://github.com/NabiWu/NYU_NanoLab_GUI/tree/main/Functionality)

### 3. Experiment Running

#### 3.a Pretreatment measurement

The pretreatment measurement is the main new feature on GUI3.0. The purpose of pretreatment is to make sure the FSCV plot get stabilized and get ready for the real measurement. The pretreatment usually takes longer than 1 hour. We base on the value of four cursors to determine whether or not we are ready for real measurement. In addition, the slope of the four cursor values in the period of 1 hour also tell you whether or not you are ready.

i. Start pretreatment measurement:

Since the GUI will fill the edit boxes with default values for frequency, scan rate, FSCV plot axis range, and cursor values. Everything you need to do is to close the directory of folder which you want to save data for and click the file name button to automatically generate the file name.

Once you finished above step, you can simply click the Start button to start the pretreatment. Since the GUI3.0 don't have ability to control the NI-DAQ, the Stop button will leave for future developer which I believe is one of the promising feature if you can directly control the start and stop on the same program. The Save Data button here is kind of redundant because the program will automatically save all needed data in the precious directory you have chosen, but in case you want to save them again, you can click this button.

ii. FSCV plot axis range setting:

The below feature shows how to setting the plot range for FSCV for all four different channel. You will be able to view the little bumps more clear by setting the range very small or view the whole FSCV plot by just using the default values shown below

The screenshot displays the 'FSCV Setup' window, which is organized into four quadrants, each representing a different channel (Ch1, Ch2, Ch3, and Ch4). Each quadrant contains two rows of input fields. The first row is labeled 'V' (Voltage) and the second row is labeled 'I' (Current). Each row has a text box for a minimum value, the word 'to', and another text box for a maximum value. In all four channels, the voltage range is set from -0.4 to 1.3, and the current range is set from -50 to 50. The entire interface is enclosed in a light gray border with a title bar at the top.

Channel	Parameter	Min Value	Max Value
Ch1	V	-0.4	1.3
	I	-50	50
Ch2	V	-0.4	1.3
	I	-50	50
Ch3	V	-0.4	1.3
	I	-50	50
Ch4	V	-0.4	1.3
	I	-50	50

iii. Pretreatment Cursor setting:

As we discuss before, you can based on the cursor values to determine whether or not you are ready for the final measurement. This GUI3.0 provides ability to find all cursor values for every 15 loops. In other word, the correspond I (current) values will update less than 5 seconds which you can easy track on them. Also, you are able to change the cursor by setting different voltage value on FSCV.

PreCursor

Ch1

V1

-0.1

I1

V1

0.8

I2

V3

0.5

I3

V4

0.6

I4

Ch2

V1

-0.1

I1

V1

0.8

I2

V3

0.5

I3

V4

0.6

I4

Ch3

V1

-0.1

I1

V1

0.8

I2

V3

0.5

I3

V4

0.6

I4

Ch1

V1

-0.1

I1

V1

0.8

I2

V3

0.5

I3

V4

0.6

I4

iv. Pretreatment analysis:

In this subsection, besides the cursor value (I), you are able to find the slope of the current value. Since at the beginning of pretreatment, the FSCV is not very stable, the slope values for four channels are not stable as well. As long as FSCV plots become stable, the slope will approximately become 0 which is another indicator to show how well you prepare for the real measurement. As shown below, you can choose which channel you want to observe and four slopes will display in the right part.

Pretreatment Analysis

CH1

Slope of I1:

Slope of I2:

Slope of I3:

Slope of I4:



v. Choose directory and save data:

By click the “Choose Folder” button, you can determine where the data will be stored in your local computer. The data will contain the current cursor values and the slope values during the whole pretreatment. As we discuss before, you should not forget to click the ‘File Name’ button to automatically generate the file name based on the Device ID, peak voltage, bottom voltage, frequency, scan rate, and the pretreatment time.

The image shows a 'Save File' dialog box with a light gray background. It contains three input fields arranged vertically. The first field is labeled 'Device ID' and contains the text 'CM\_N5A\_57\_C1'. The second field is labeled 'Choose Folder' and is a button. The third field is labeled 'File Name' and is a button.

3.b Real measurement

Real measurement is the main feature of GUI3.0. Usually, after you finished the pretreatment, you should start the real measurement. The real measurement is very similar as the pretreatment except the time duration. For pretreatment, you probably will wait for over 1 hour; however, in the real measurement you only need to less than 5 min (normally 2 min)

i. Start pretreatment measurement:

Since the GUI will fill the edit boxes with default values for frequency, scan rate, FSCV plot axis range, and cursor values. Everything you need to do is to close the directory of folder which you want to save data for and click the file name button to automatically generate the file name. Also, you might double check the duration, in case you want to fetch more data. (The default duration is 2min)

Once you finished above step, you can simply click the Start button to start the real measurement. Since the GUI3.0 don't have ability to control the NI-DAQ, the Stop button will leave for future developer which I believe is one of the promising feature if you can directly control the start and stop on the same program. The Save Data button here is kind of redundant because the program will automatically save all needed data in the precious directory you have chosen, but in case you want to save them again, you can click this button.

ii. FSCV plot axis range setting:

The below feature shows how to setting the plot range for FSCV for all four different channel. You will be able to view the little bumps more clear by setting the range very small or view the whole FSCV plot by just using the default values shown below

**-FSCV Setup**

Ch1				Ch2			
V	-0.4	to	1.3	V	-0.4	to	1.3
I	-50	to	50	I	-50	to	50

Ch3				Ch4			
V	-0.4	to	1.3	V	-0.4	to	1.3
I	-50	to	50	I	-50	to	50

iii. Real Measurement Cursor setting:

Cursors in this sections are exactly same as those in pretreatment. This GUI3.0 provides ability to find all cursor values for every 15 loops. In other word, the correspond I (current) values will update less than 5 seconds which you can easy track on them. Also, you are able to change the cursor by setting different voltage value on FSCV. The cursor values also make sure whether or not you are fetching the correct data.

**-PreCursor**

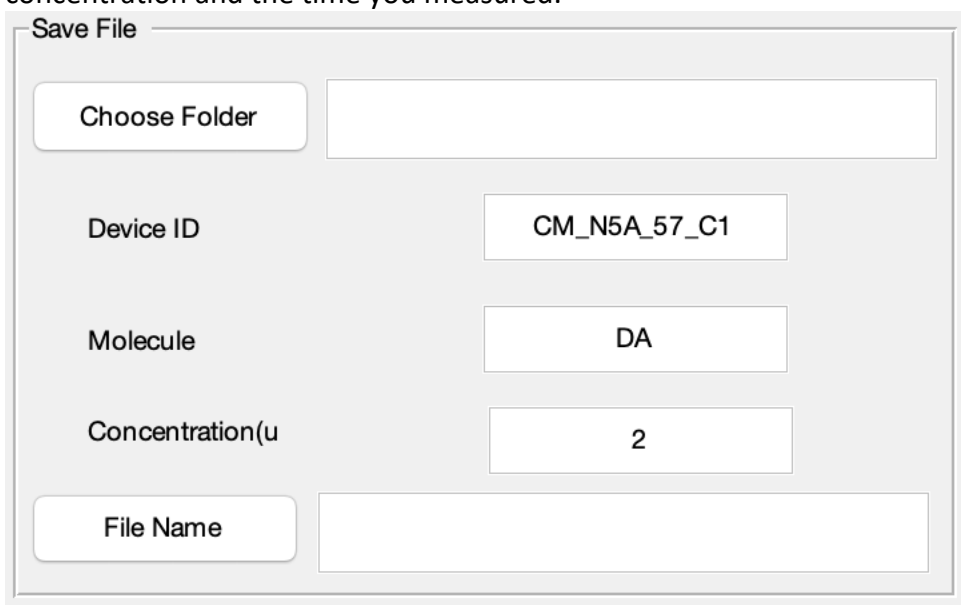
Ch1				Ch2			
V1	-0.1	I1		V1	-0.1	I1	
V1	0.8	I2		V1	0.8	I2	
V3	0.5	I3		V3	0.5	I3	
V4	0.6	I4		V4	0.6	I4	

Ch3				Ch1			
V1	-0.1	I1		V1	-0.1	I1	
V1	0.8	I2		V1	0.8	I2	
V3	0.5	I3		V3	0.5	I3	
V4	0.6	I4		V4	0.6	I4	

iv. Choose directory and save data:

By click the “Choose Folder” button, you can determine where the data will be stored in your local computer. The data will contain the current cursor values and the slope values during the whole pretreatment. As we discuss before, you should not forget to click the ‘File Name’ button to automatically generate the file name based on the Device ID, peak voltage, bottom voltage, frequency, scan rate, duration, type of molecule, concentration and the time you measured.



The image shows a 'Save File' dialog box with a light gray background and a thin border. At the top left, the title 'Save File' is displayed. Below the title, there are four main sections. The first section contains a 'Choose Folder' button and an empty text input field. The second section contains the label 'Device ID' and a text input field containing 'CM\_N5A\_57\_C1'. The third section contains the label 'Molecule' and a text input field containing 'DA'. The fourth section contains the label 'Concentration(u)' and a text input field containing '2'. At the bottom, there is a 'File Name' button and a large empty text input field.

Field	Value
Choose Folder	
Device ID	CM_N5A_57_C1
Molecule	DA
Concentration(u)	2
File Name	

## 4. Data Analysis

### 4.a Pretreatment Analysis



As the figure shown above, you can click the current button to directly plot the cursor current value during the pretreatment measurement as well as the slope button will should you the slope changes during the whole pretreatment. In the beginning of the plot, you are expected to see unstable values for both current and slope plot; however, in the end of the pretreatment, you are expected to see for the current value will converge to a stable value and slope will all converge to approximately zero.

### 4.b real measurement data analysis:

The real measurement data analysis contains two parts. The ramp signal analysis and the N-shape analysis which both are different kinds of input signals.

As for the ramp signal analysis, the GUI will choose the most recent real measured data to do the analysis. The main idea of analysis is to choose certain cycles to find the properties in order to determine whether or not your measurement is successful. For more detailed data analysis methods, you can view this link:

[https://github.com/NabiWu/NYU\\_NanoLab\\_GUI/tree/main/FINAL%20GUI%20\(Everthing%20Needed\)/Data%20Analysis](https://github.com/NabiWu/NYU_NanoLab_GUI/tree/main/FINAL%20GUI%20(Everthing%20Needed)/Data%20Analysis)

The above link contains all detailed algorithm of how we did the analysis with easy and understandable comments. Feel free to dig deeper and may find ways to optimize them. As for the N-shape signal, we use the same data analysis method, except you will not have freedom to choose both the starting cycle and ending cycle; you can only choose the starting cycle which GUI only allow certain number of cycle information to keep the validity of the analysis. The real analysis section in GUI looks like this:

Measurement

Ramp Signal

DA Cycles  to

Channel1 Channel2

Channel3 Channel4

NShape

PBS Cycles start at

DA Cycles start at

Channel1 & 2 Channel3 & 4

#### 4.c Machine Learning

The machine learning part is one of the most interesting part left for future developer. Previously, I implemented the another program to predict the concentration of the Dopamine using the multiple linear regression algorithm with the coordinating gradient descent to optimize the loss. You will find more interesting information in these two link:

[https://web.stanford.edu/~hastie/glmnet/glmnet\\_alpha.html](https://web.stanford.edu/~hastie/glmnet/glmnet_alpha.html)

[http://web.stanford.edu/~hastie/glmnet\\_matlab/intro.html](http://web.stanford.edu/~hastie/glmnet_matlab/intro.html)