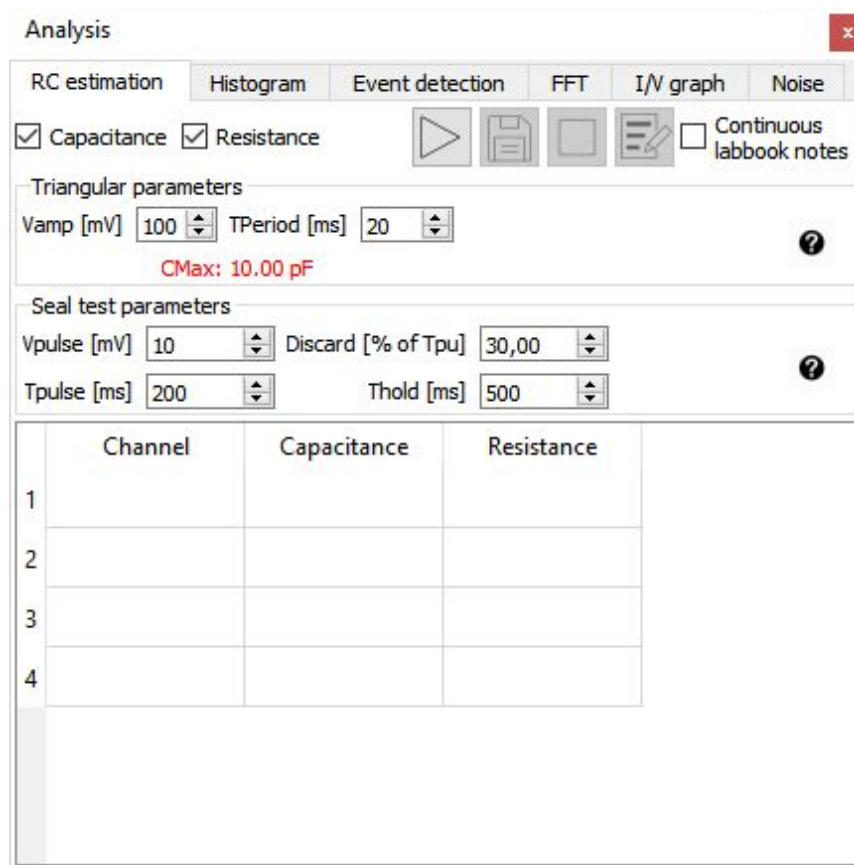


# Online Analyses



## Revision History

Date	Version	Description
05/03/2020	1.1	Revised
16/01/2020	1.0	First version of document



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## Analyses overview

The Online Analyses module contains all the analyses computed by the software in real time while the data are visualized and recorded and enables users to perform some common statistical analysis, usually done by scientists only during the post processing analysis of data.

In particular EDR offers these predefined online analyses selectable from the Analysis menu:

- RC estimator;
- Current histogram;
- Current events detection;
- Current spectrum;
- I/V graph;
- Noise reporter.

The Resistance and Capacitance estimator and the Noise reporter are always enabled, while all the other analysis are enabled under license (see the “EDR Installation and Licensing” guide for details on how to install the license).

## New analyses requests




It is possible to suggest new analyses to be added in the next software releases.

To do so write to [support@elements-ic.com](mailto:support@elements-ic.com) and provide:

- A brief explanation of the analysis;
- A minimum set of specifications (e.g., parameters settable by the user, useful noise reductions or spurious data rejection, etc.);
- A sample recording with expected analysis result (e.g., obtained with Python, Matlab, etc.);
- If available, any useful reference is very welcome (e.g., reference to paper/book explaining the analysis, code/pseudocode, etc.).


## Analysis common features

### Control buttons

Each online analysis has a dedicated tab but all the analyses have common buttons respectively to start , to save data analysis into a .csv file  and to stop the active analysis .




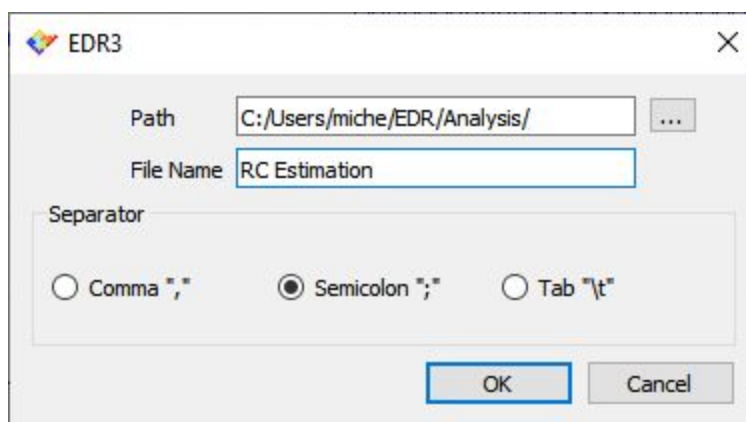
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Some of the analysis that accumulate data in memory (such as histogram) have a “reset analysis results” button  to reset plot and data analysis.

To note analysis results to Lab book click on the “copy to labbook” button .

## Analysis export

All analyses results can be exported to .csv files. In order to do so, click the Export button . In the dialog window that will open browse for a location to save the .csv file, select a filename and select the value separator (the comma may create conflicts in some applications depending on your local machine configuration).



## Analysis zoom

All the plots of the analyses can be zoomed by selecting a rectangular area to be zoomed: left click in a corner of the area to zoom, drag the mouse cursor to the opposite corner of the area and finally release the left button. To zoom back right click in any point of the plotting area.



# Analyses description

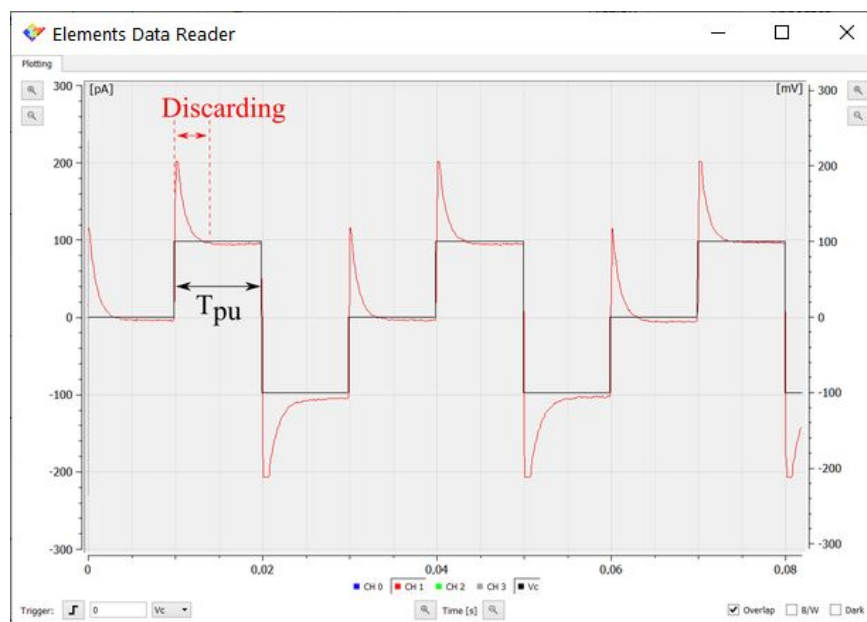
## RC estimator

To estimate Resistance and Capacitance of the DUT (considering a simple RC paralel model) check both the checkboxes and click the Start button. EDR software will start to apply alternatively triangular waves and seal test protocols to estimate respectively capacitance and resistance values.

	Channel	Capacitance	Resistance
1	1	1.776 pF	-
2	2	1.746 pF	-
3	3	1.781 pF	1.037 GΩ
4	4	2.187 pF	1.023 GΩ

The parameters of the triangular wave and of seal test can be set (move the mouse over the help icon and on the “Discard [% of Tpu]” textfield for more information).

The algorithm estimates the Resistance ( $R = \Delta V / \Delta I$ ) value considering the average current and voltage values and neglecting the selected percentage of Tpu.



Capacitance is estimated considering the equation  $C = \Delta I / \Delta(dV/dt)$ , so considering the current jump corresponding to the voltage slope change when the triangular wave crosses a minimum or a maximum.

When the “-” is shown instead of the estimated value it means that EDR algorithm cannot properly calculate, e.g. if the denominator of an equation is negative for resistance estimation. Some strategies to improve the signal quality when the RC estimation fails include:

- If the current noise amplitude is comparable to the current signal amplitude increase the protocol duration and reduce the sampling rate, in order to have the same amount of samples with lower noise, increase the protocol amplitude to increase the signal to noise ratio, and use a lower current range for a better signal resolution;
- If the current is saturating reduce the protocol amplitude and/or increase the current range.

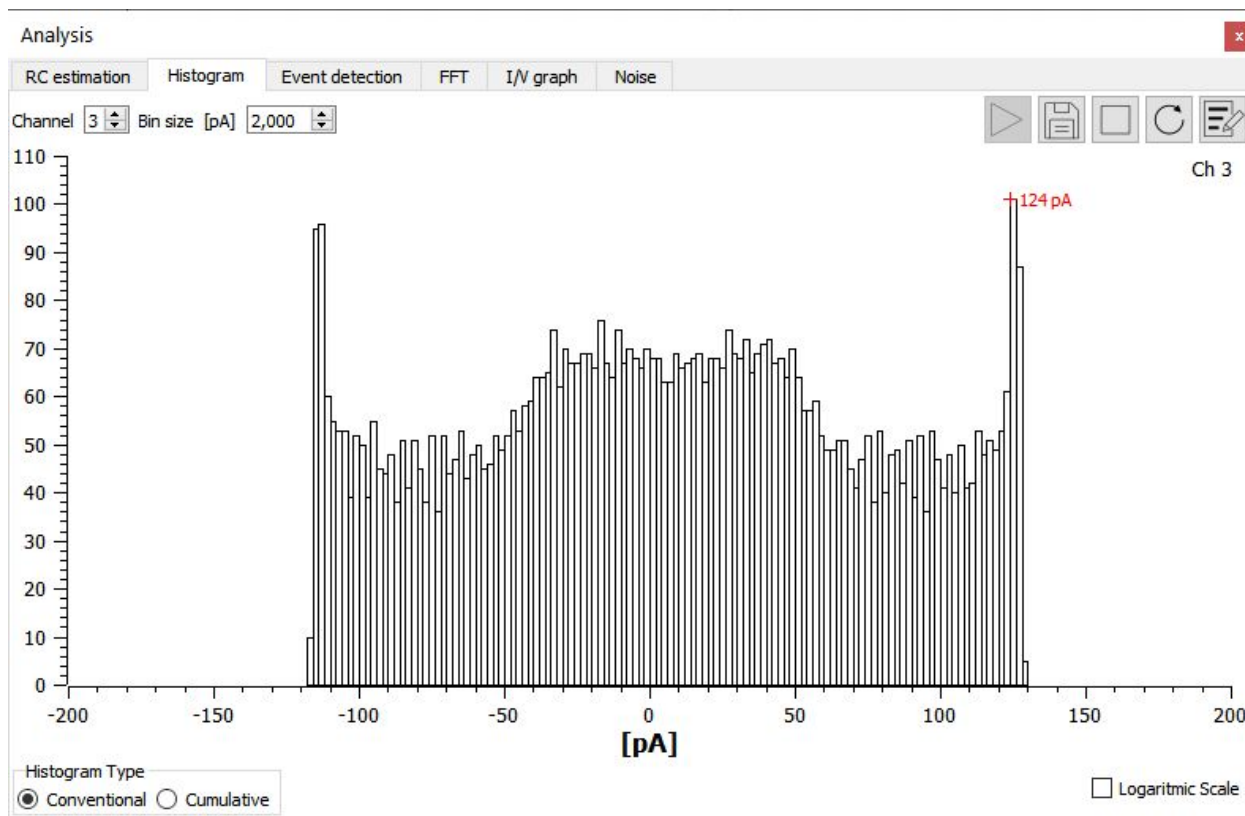
## Current histogram

To compute a current histogram select Histogram tab from the Analysis menu.

Select the current channel you want to apply the analysis to (for multichannel devices) and the histogram bin size, i.e. the width of each bar of the histogram: increasing the bin size reduces the resolution and the variance of the histogram.


Click Start to actually perform the analysis.

This analysis can optionally visualize the cumulative histogram or set a logarithmic scale.



## Current event detection

To detect current events select Event detection tab from the Analysis menu.

Select the current channel you want to apply the analysis to (for multichannel devices) and click  button to set analysis' parameters. In the window that will open select if you want to identify positive or negative events. Set the remaining analysis parameters in order to correctly detect the events you are interested in and reject spurious events and click CLOSE button.

Click Start to actually perform the analysis. This analysis will identify as events those intervals that comply with the following rules:

- The event starts when the current passes the First threshold with a rising edge (or falling edge for negative pulses detection);
- The event ends when the current passes the Second threshold with a falling edge (or rising edge for positive pulses detection);
- Events outside the duration range defined are rejected.

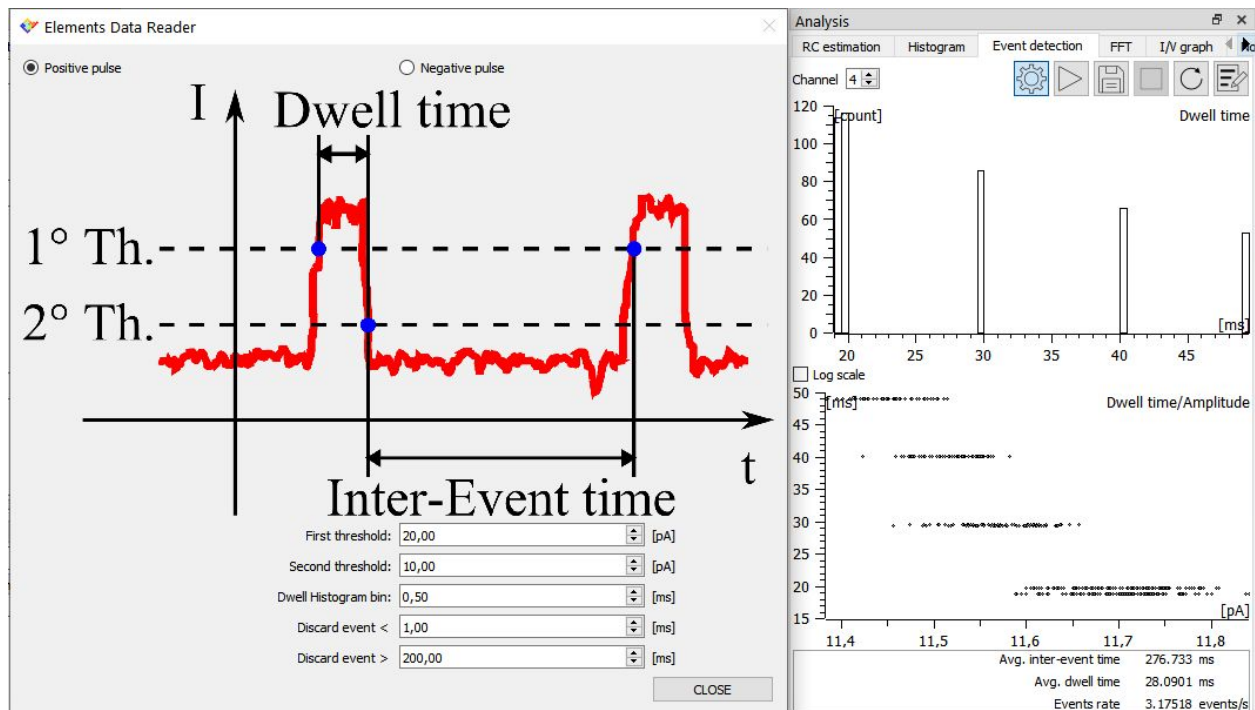
The analysis result will include the following:

- A histogram of the duration of the detected events (dwell time histogram);



- A histogram of the duration of the intervals between consecutive events (inter-event time histogram);
- A dwell time/amplitude scatter plot that shows the relation between the duration and the mean amplitude of each event;
- A report including the average inter event time, the average event duration and the average events rate.

This analysis can optionally visualize the histogram on a logarithmic scale.



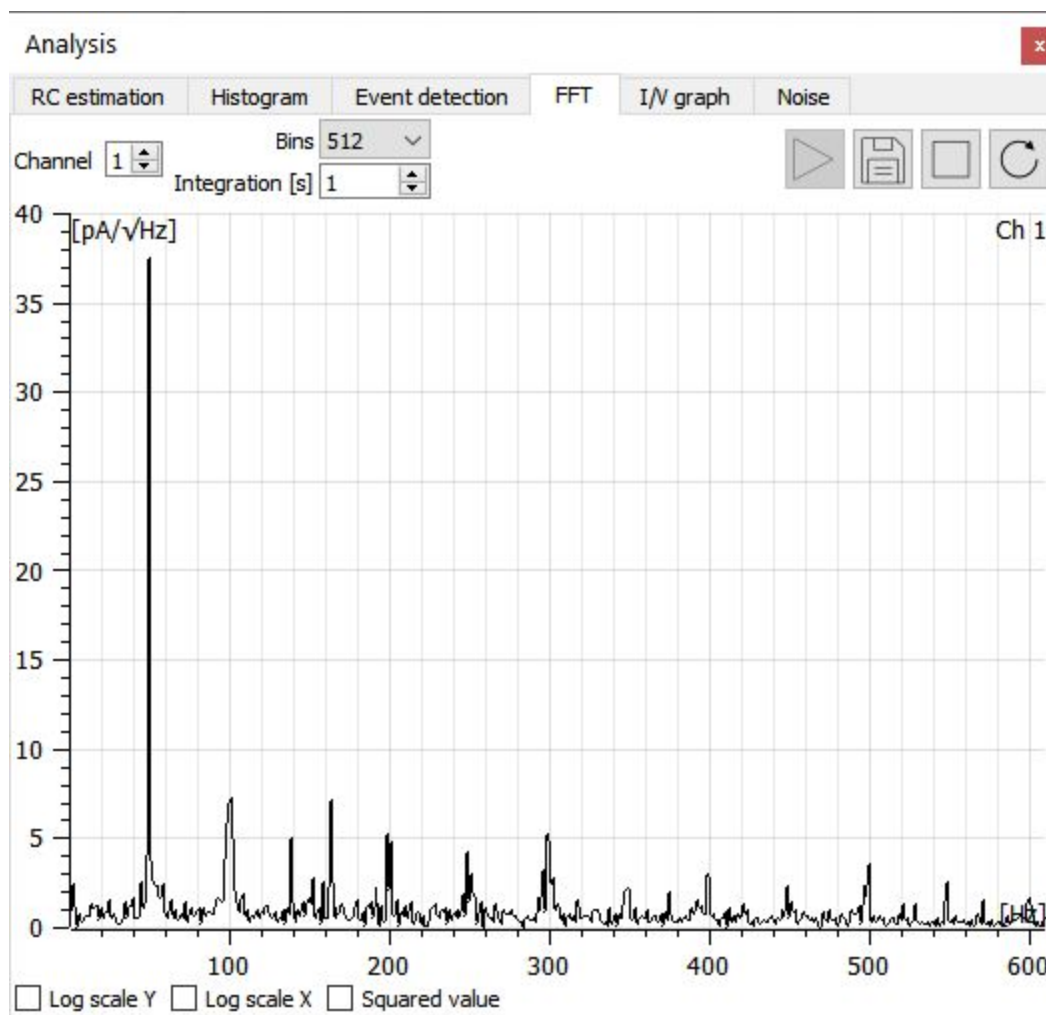
## Current spectrum

To compute a current spectrum select FFT tab from the Analysis menu.

Select the current channel you want to apply the analysis to (for multichannel devices), the integration period and the number of frequency bins, i.e. the number of points between 0Hz and SR/2: increasing the number of bins increases the resolution and the variance of the spectrum.


Click Start to actually perform the analysis. The spectrum is computed by computing the FFT over windows of  $2*N$  bins current samples, keeping only the first half of the spectrum, and finally taking the root mean square of the modulus of the computed FFTs.

This analysis can optionally visualize the power spectrum or set logarithmic axis.



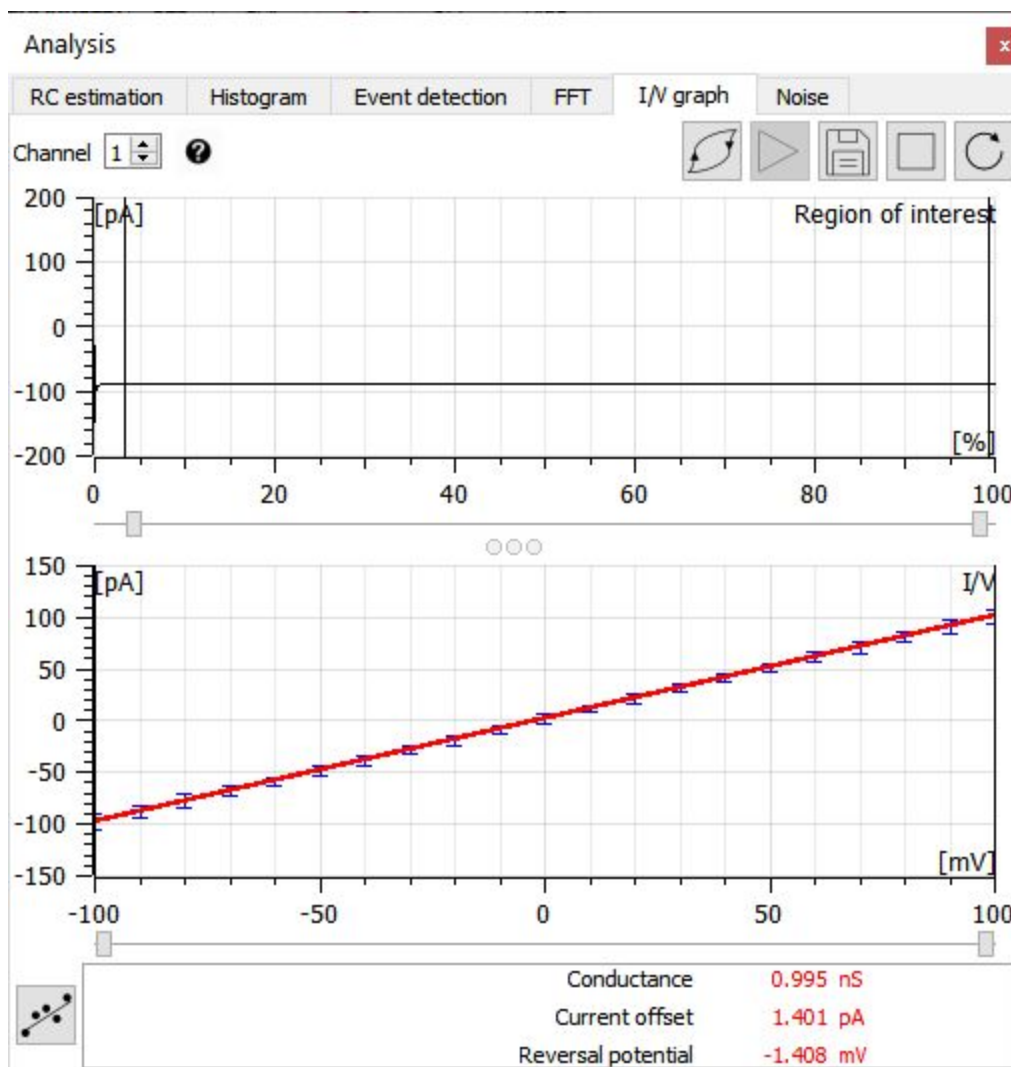
## I/V graph


To compute an I/V graph select I/V graph tab from the Analysis menu.


Select the current channel you want to apply the analysis to (for multichannel devices). It is possible to use the cursors under the Region of interest selection plot to reduce the interval over which the current statistics are computed, e.g., by moving slightly to the right the leftmost cursor it is possible to neglect capacitive peaks usually located at the beginning of voltage steps (move the mouse over the help icon  for more information).

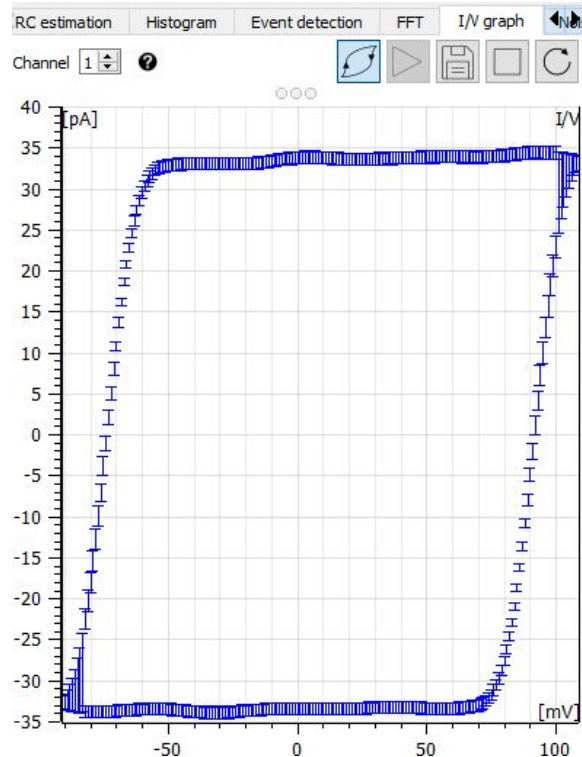
Start a voltage protocol (e.g. Conductance estimation protocol or a Ramp protocol to have a varying voltage) and click Start to actually perform the analysis. The analysis will compute the current mean value and standard deviation over each interval in which the voltage is constant, taking into account the limits set with the Region of interest plot.





Clicking the linear fit button  a linear fit of the I/V graph will be performed including only the points within the interval identified by the cursors below the I/V graph plot. Performing the linear fit provides also a brief report including the estimated conductance, the current offset and the reverse potential.

In case the hysteresis button  is pressed, intervals with the same voltage value are treated separately if they belong to a rising sequence or to a falling sequence.



## Noise reporter

To have an indication of the noise and offset values for every channel select Noise tab from the Analysis menu.

Computation period can be set and the RMS (root mean square) current noise values and the mean current values are reported and can be saved either in a .csv file or noted into the lab book.

Save offset button (when enabled) is used to record the mean current values, in order to be used to cancel open input current offsets of the amplifier (see the “Current offset compensations” guide for details).

Channel	Mean	RMS
1 1	1.3326 pA	0.126181 pA
2 2	1.57504 pA	0.12249 pA
3 3	0.672013 pA	0.132037 pA
4 4	1.26174 pA	0.125022 pA