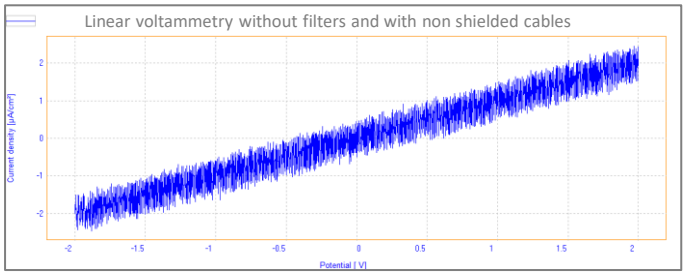
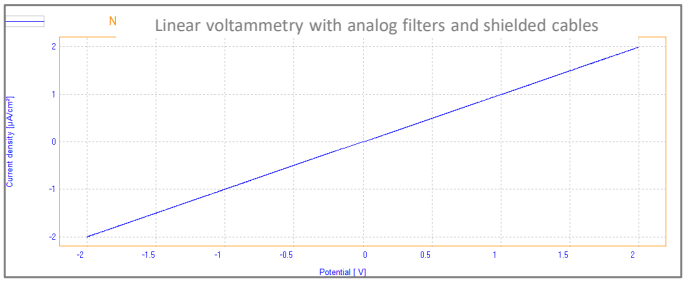
Application Note

Basics
AP-ORI04

How to deal with noisy signal





This Application Note describes what is the noisy signal and how to avoid it.

Origalys Electrochem

2010 - ORIGALYS - 2020
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What is noise?

Noise is undesired peak, noise disturbs, swamps and masks a signal being measured. Signal levels are increased in order to measure something stable. Noise can come from various electrical or electronic sources:

- ✓ **Computers**: it has Switched mode power supplies, it creates the most magnetic interference.
- ✓ **Electromagnetic field**: waves from network generate noise, such as Power lines and domestic current: 50 Hz (or 60 Hz in the USA) .

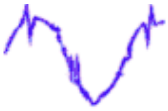
All of these sources are picked up by the experiment and mainly by long cell cable runs. A high impedance reference cable is particularly susceptible. Moreover, in case of non shielded cables, longer the cable is, higher the picking of noise could be.

Non shielded

Shielded

HOW SHIELDED CABLES WORK

Non shielded cable



Noisy curve

Shielded cable

Curve without noise

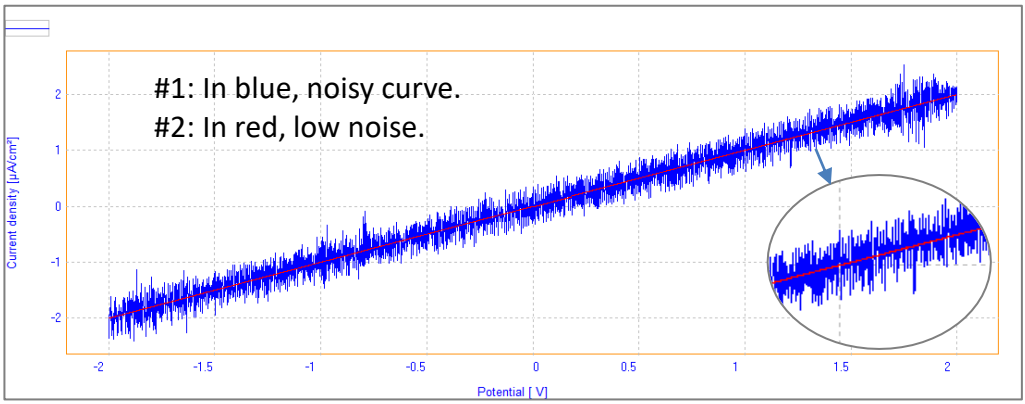
What is noise?

#1 Blue curve

#2 Red curve

EXAMPLE: IMPACT OF CABLES

Curve	#1 Blue	#2 Red
Type of cable	Non shielded banana/banana	Shielded BNC/BNC
Length of cable	1 m	0,10 m
Level of noise	The system attracts all the parasites from the environment	The noise is divided by 10 due to the efficiency of the cable



Limiting noise

A noisy signal is undesired, but reflects real environment conditions. At any time, the instrument will measure it. Knowing the source of the noise will help limiting it, if necessary. For instance, if the noise is coming from any electrical devices, it's clearly an unwanted parasite.

But, if the noise is coming from the experiment itself, it is very important to measure it. In this case, limiting it could be counterproductive.

TOOLS TO LIMIT NOISE

That's why, OrigaLys recommends to follow some easy tools to limit noise from undesired parasites:

- ✓ **Shielding**: both instrument, cable and around the cell. For low current application, a Faraday cage is necessary to protect the cell from environmental parasites.

Shielded BNC plug

Shielded UHF plug

- ✓ **Positioning**: place the instrument and cell away from high noise sources. Plug the instrument into a different mains socket than used by noisy appliances. Be careful with the Working Electrode, if the pin is too big, it could attract more parasites.

Limiting noise

- ✓ **Grouping**: group each wire of an electrode cable together, so if a cable experiences any noise, the noise will be present on all wires of the same cable and will cancel out.
- ✓ **Short cable**: in case of non shielded cables, shorter the cable is, lower the noise will be.
- ✓ **Power cable**: verify the well connectivity of the power cord. If the mass is not balanced, the system will be floating and so attract parasites.

EURO Power cord

Mass balanced

Main with ground

Floating

Main without ground

- ✓ **Ground**: according to the device, check the ground connection. Indeed, the ground could be balanced by the power cord and/or the PC connection. For main connectivity, see above. For PC connection, check the power cord of the desktop. If possible, avoid using laptop on battery or laptop without ground facility.

This power cord is without ground. The PC connected to the main, by this way, is not mass balanced so does a floating instrument connected to this PC.

Current ranges

Understanding that a noisy signal is unwanted and not suitable for publications or presentations. With its software OrigaMaster 5 and OrigaViewer, OrigaLys allows you to reduce the noise and get a good curve shape.
To proceed, you can choose from treatments during the experiment or/and after it:

TOOLS TO LIMIT NOISE WITH ORIGALYS PC SOFTWARE

✓ **Current range**: fixing the current ranges according to the level of current of the experiment brings a better resolution and so a lower noise. Most of the time, the Auto current is suitable. Verify the level of both signal and noise; does it corresponds to 0.1% of signal or 10% or more?

Properties

Display all | Details | Graph

Pot. Cyclic Voltammetry	
Potential 0 (mV)	200
Potential 1 (mV)	-300
Potential 2 (mV)	200
Scan rate (mV/sec.)	100, 0.01, 1
Sampling rate	1:1
Maximum current (mA)	100
Minimum current (mA)	-100
Ohmic Drop Comp.	No
Maximum range	Auto
Minimum range	Auto
Analog Filter	Auto
Digital Filter	0
Cycle	10
Open circuit at end	Yes
Save points	Yes
Auxiliary input	No

Auto current range
For OrigaFlex OGF500

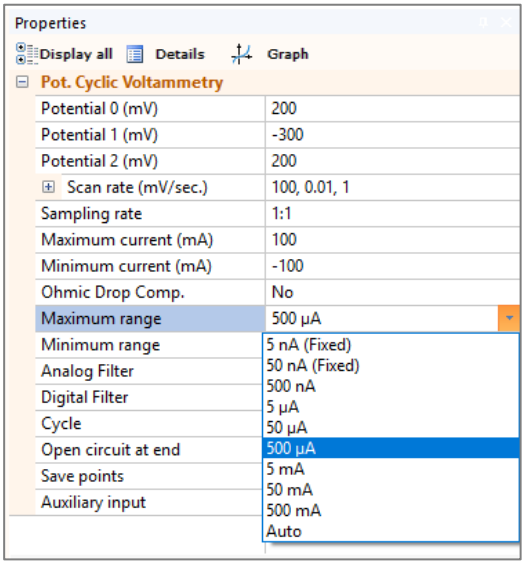
Properties

Display all | Details | Graph

Pot. Cyclic Voltammetry	
Potential 0 (mV)	200
Potential 1 (mV)	-300
Potential 2 (mV)	200
Scan rate (mV/sec.)	100, 0.01, 1
Sampling rate	1:1
Maximum current (mA)	100
Minimum current (mA)	-100
Ohmic Drop Comp.	No
Maximum range	500 µA
Minimum range	500 µA
Analog Filter	Auto
Digital Filter	0
Cycle	10
Open circuit at end	Yes
Save points	Yes
Auxiliary input	No

500 µA current range
For OrigaFlex OGF500

Current ranges



According to the model, you get different current ranges. Indeed, each device has its own ranges.

See below the full list of current ranges

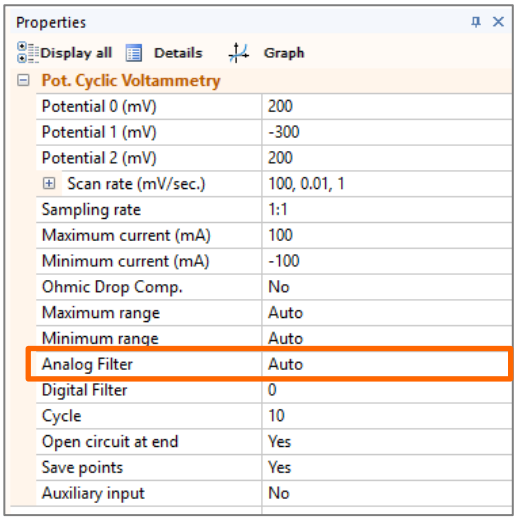
	Current ranges
OrigaStat – OGS080	9 decades 1 nA, 10 nA, 100 nA, 1 µA, 10 µA, 100 µA, 1 mA, 10 mA and 100 mA
OrigaStat – OGS100	9 decades 1 nA, 10 nA, 100 nA, 1 µA, 10 µA, 100 µA, 1 mA, 10 mA and 100 mA
OrigaStat – OGS200	9 decades 20 nA, 200 nA, 2 µA, 20 µA, 200 µA, 2 mA, 20 mA, 200 mA and 2 A
LandStat	9 decades 1 nA, 10 nA, 100 nA, 1 µA, 10 µA, 100 µA, 1 mA, 10 mA and 100 mA
OrigaFlex – OGF500	9 decades 5 nA, 50 nA, 500 nA, 5 µA, 50 µA, 500 µA, 5 mA, 50 mA and 500 mA
OrigaFlex – OGF01A	9 decades 10 nA, 100 nA, 1 µA, 10 µA, 100 µA, 1 mA, 10 mA, 100 mA and 1 A
OrigaFlex – OGF05A	6 decades 50 µA, 500 µA, 5 mA, 50 mA, 500 mA and 5 A

Analog Filters

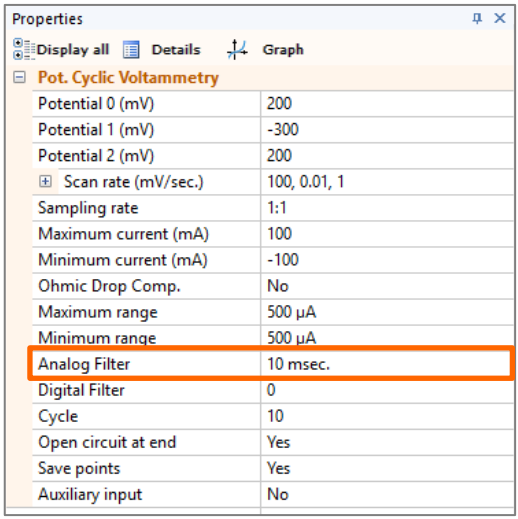
Fixing the current range is a good way to reduce the noise and use the best resolution, but it's only a step. The analog filter is the most efficient option to reduce the noise and get a smooth curve. With our software, this data is expressed in seconds (sec.).

TOOLS TO LIMIT NOISE WITH ORIGALYS PC SOFTWARE

✓ **Analog filters**: the value of the automatic filter, on the measurements of Potential and Current is set according to the measurement period (also called step duration or dt).



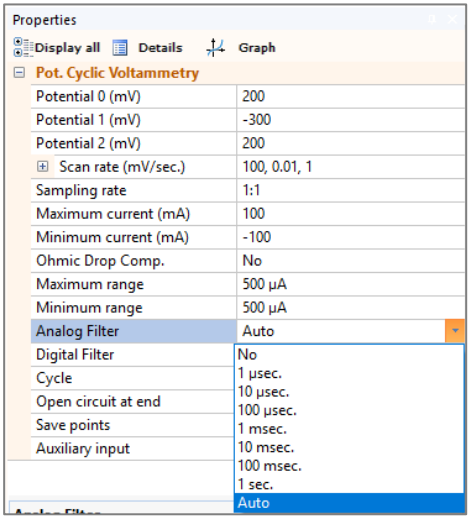
Analog filter = Auto



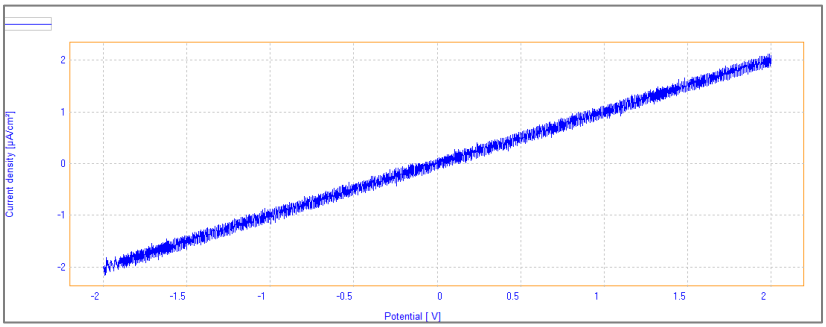
Analog filter = 10 msec.

Available filters in sec.:
1 µsec, 10 µsec, 100 µsec, 1 msec, 10 msec, 100 msec & 1 sec.
Equivalence in Hz:
1 MHz, 100 kHz, 10 kHz, 1 kHz, 100 Hz, 10 Hz & 1 Hz.

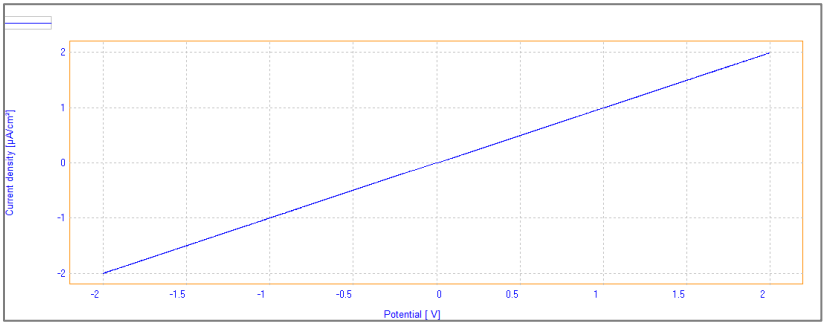
Analog Filters



1. Select the level of Analog filter: No filter, Auto filter or a manual filter.
2. Check the Step Duration in the scan rate section. The filter has to be lower than the step duration. For instance: if dt = 11 ms, then filter = 1 ms.
3. Run a first experiment
4. Adapt the filter if necessary. A too strong filter totally changes the curve shape.



Pot. Linear voltammetry without Analog filter



Pot. Linear voltammetry with AUTO Analog filter

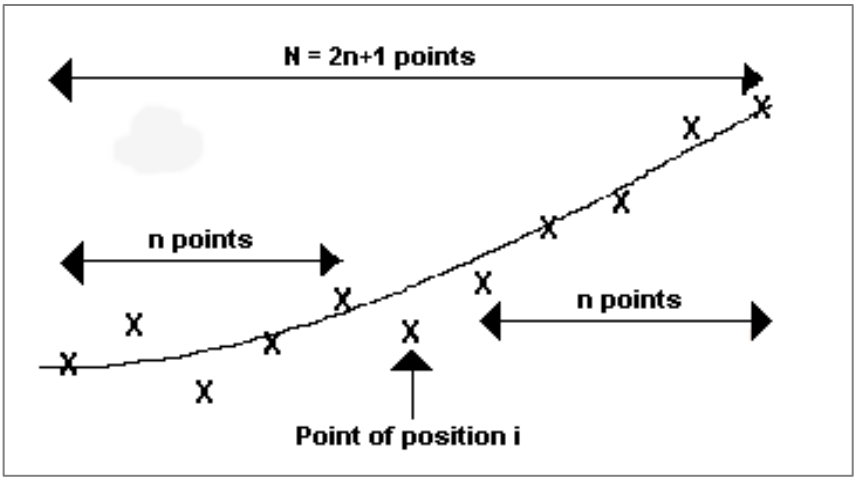
In case the Analog filter is not enough, Origalys provides another type of filter: a digital one, from the PC Software. This option may be performed during the measurement (on real time) and/or after the experiment (post-treatment). The system is performing a smoothing, according to a value from 0 to 20.

TOOLS TO LIMIT NOISE WITH ORIGALYS PC SOFTWARE

✓ **Digital filters**: the software uses a mathematical process based on the formula:

N = 2 n (Digital Filter) + 1

Value i (see the figure below) is replaced by the average of the 2n + 1 values with a coefficient of n-j for each value i±j value (j is an integer between 1 and n). The first n points and last n points of a curve can therefore not be replaced by their average.



Digital filters

Properties

Display all | Details | Graph

Pot. Cyclic Voltammetry

Potential 0 (mV)	200
Potential 1 (mV)	-300
Potential 2 (mV)	200
Scan rate (mV/sec.)	100, 0.01, 1
Sampling rate	1:1
Maximum current (mA)	100
Minimum current (mA)	-100
Ohmic Drop Comp.	No
Maximum range	Auto
Minimum range	Auto
Analog Filter	Auto
Digital Filter	0
Cycle	10
Open circuit at end	Yes
Save points	Yes
Auxiliary input	No

Digital filter = 0 = No

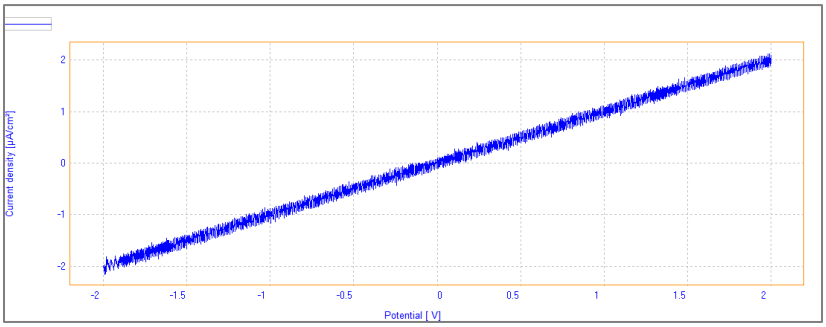
Properties

Display all | Details | Graph

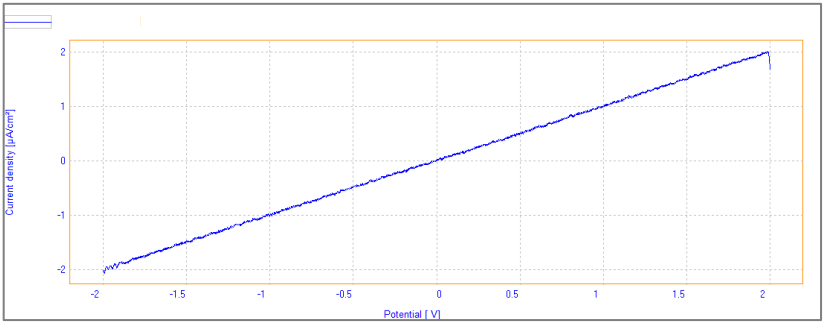
Pot. Cyclic Voltammetry

Potential 0 (mV)	200
Potential 1 (mV)	-300
Potential 2 (mV)	200
Scan rate (mV/sec.)	100, 0.01, 1
Sampling rate	1:1
Maximum current (mA)	100
Minimum current (mA)	-100
Ohmic Drop Comp.	No
Maximum range	Auto
Minimum range	Auto
Analog Filter	Auto
Digital Filter	5
Cycle	10
Open circuit at end	Yes
Save points	Yes
Auxiliary input	No

Digital filter = 5



Pot. Linear voltammetry without Digital filter



Same curve with a Digital filter = 10 (medium)

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