



Getting Started with EC-Lab[®]:

Tafel Plot

V1

Getting Started EC-Lab: Tafel

March 2024



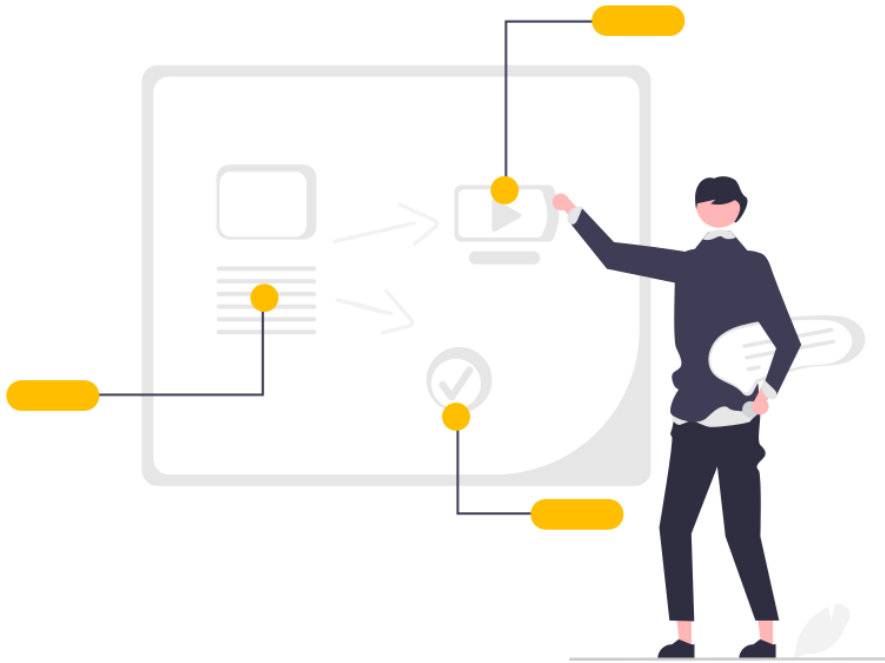
Overview and quick access

■ Procedure

- Launch the experiment
 - [Step 0](#): Connect instrument and select channel
 - [Step 1](#): Add Tafel Plot technique
 - [Step 2](#): Set Tafel Plot parameters
 - [Step 3](#): Optimize the measurement
 - [Step 4](#): Set general parameters
 - [Step 5](#): Launch the measurement
 - [Step 6](#): Add additional experiments
- Investigate the result
 - [Step 7](#): Read the graph
 - [Step 8](#): Analyse the data with Tafel Fit

■ Find out more

- [For supplementary information](#)
- [Need help?](#)
- [FAQ](#)

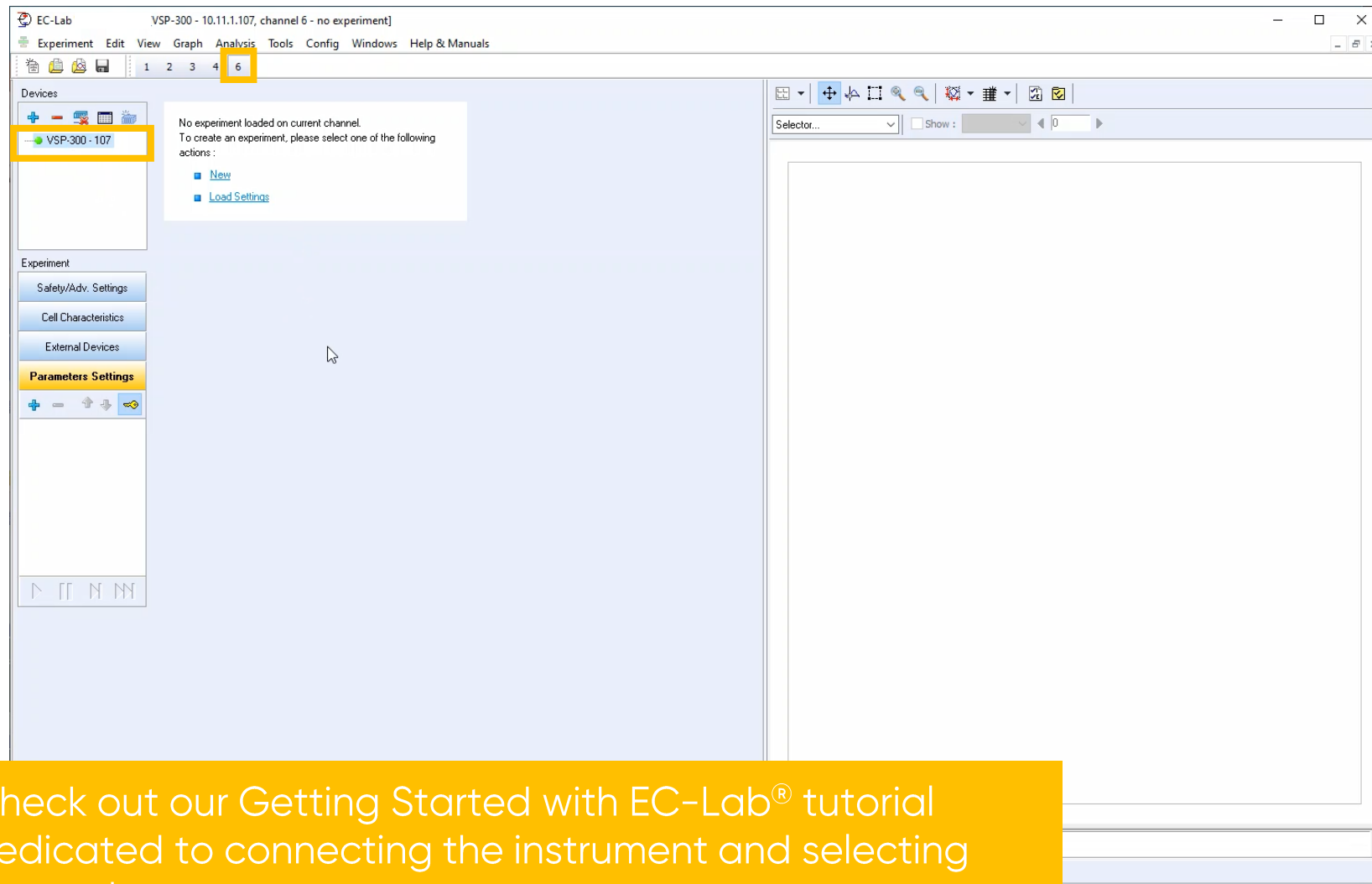


Procedure



Step 0: Connect instrument and select channel

- Connect instrument and select channel

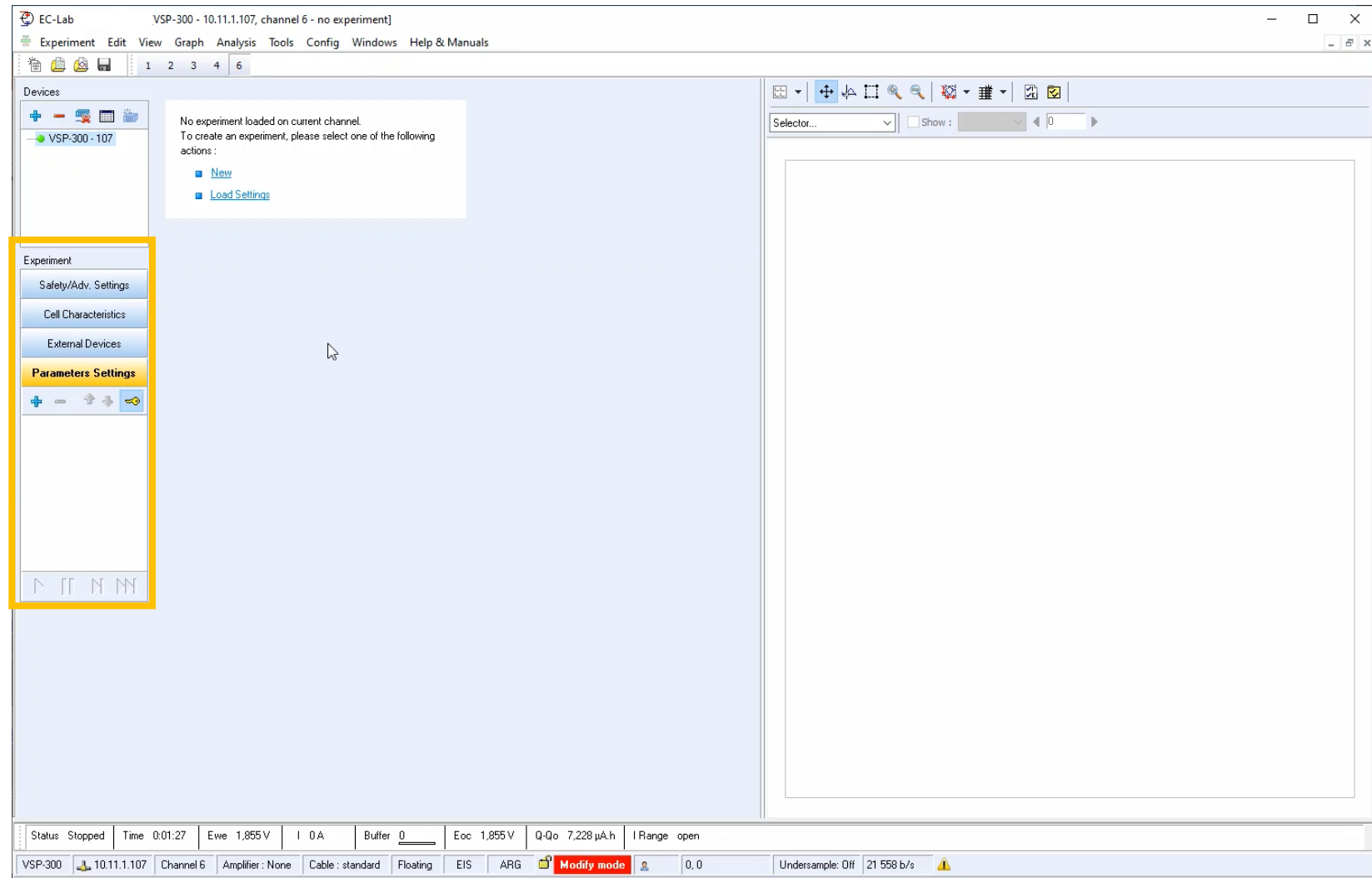


Check out our Getting Started with EC-Lab® tutorial dedicated to connecting the instrument and selecting channels.



Step 0: Connect instrument and select channel

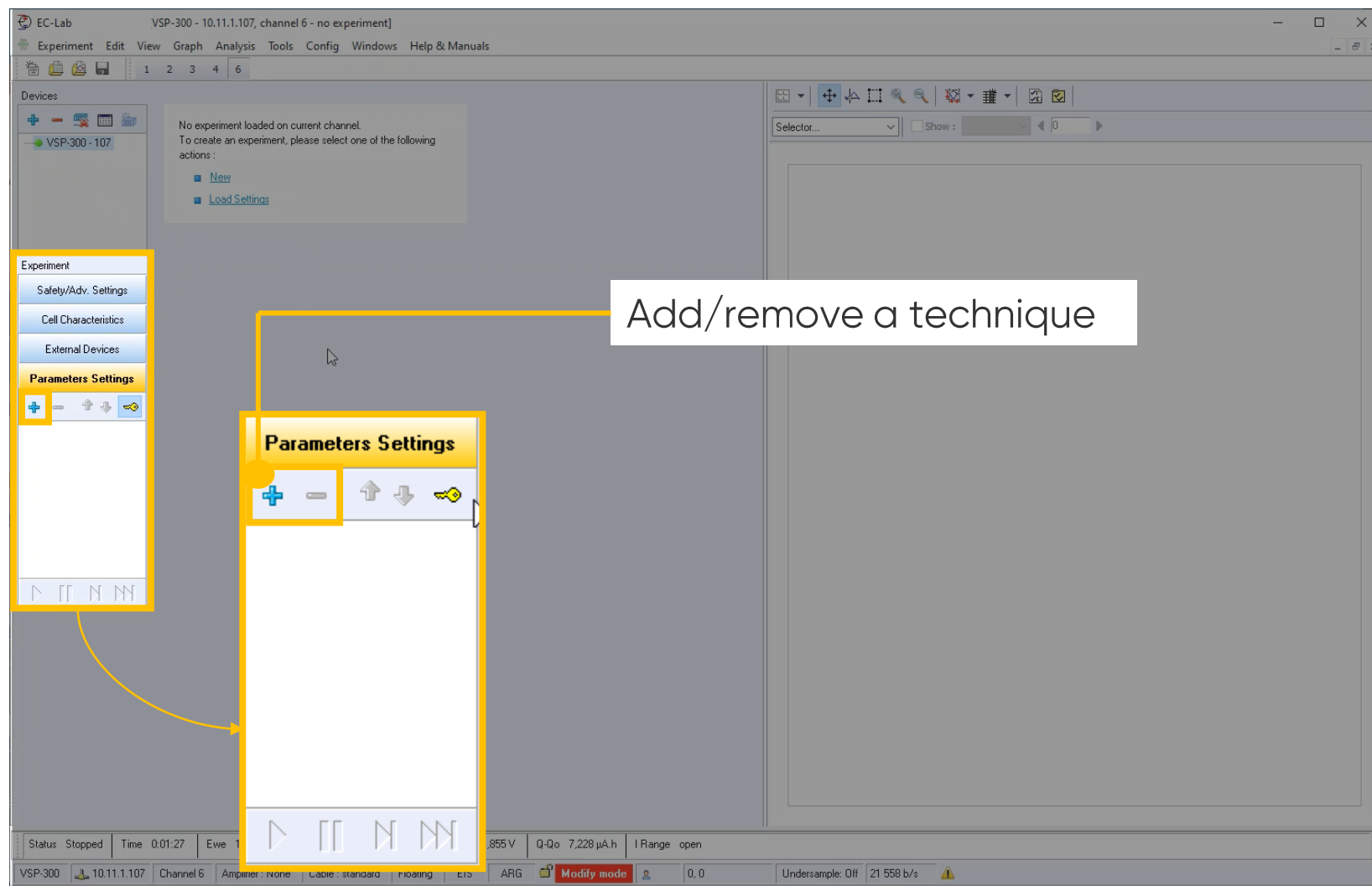
- When the instrument and channel are selected, the user can set the experiment

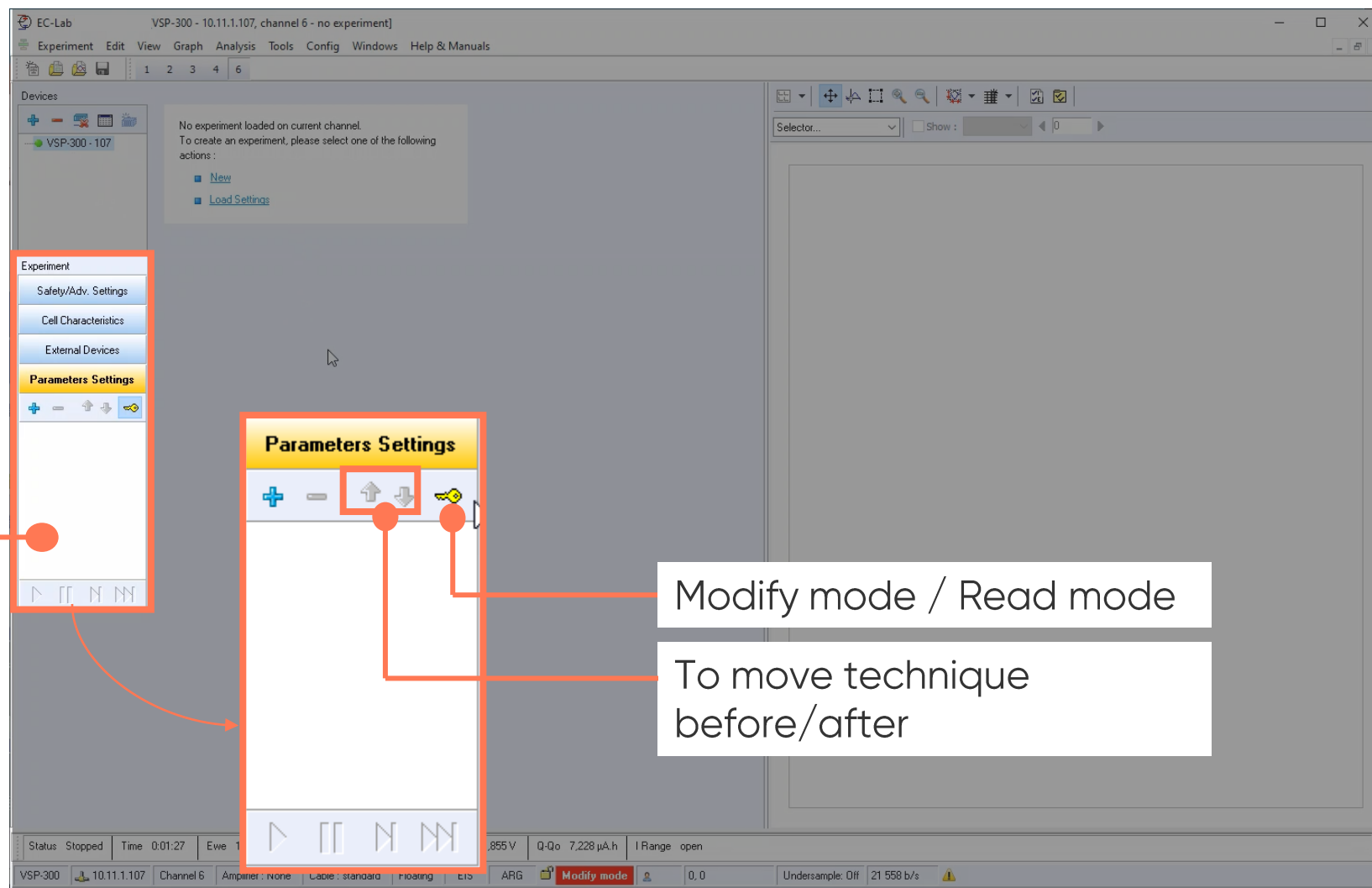




Step 1: Add Tafel Plot technique

- Click on + to add a technique in the list



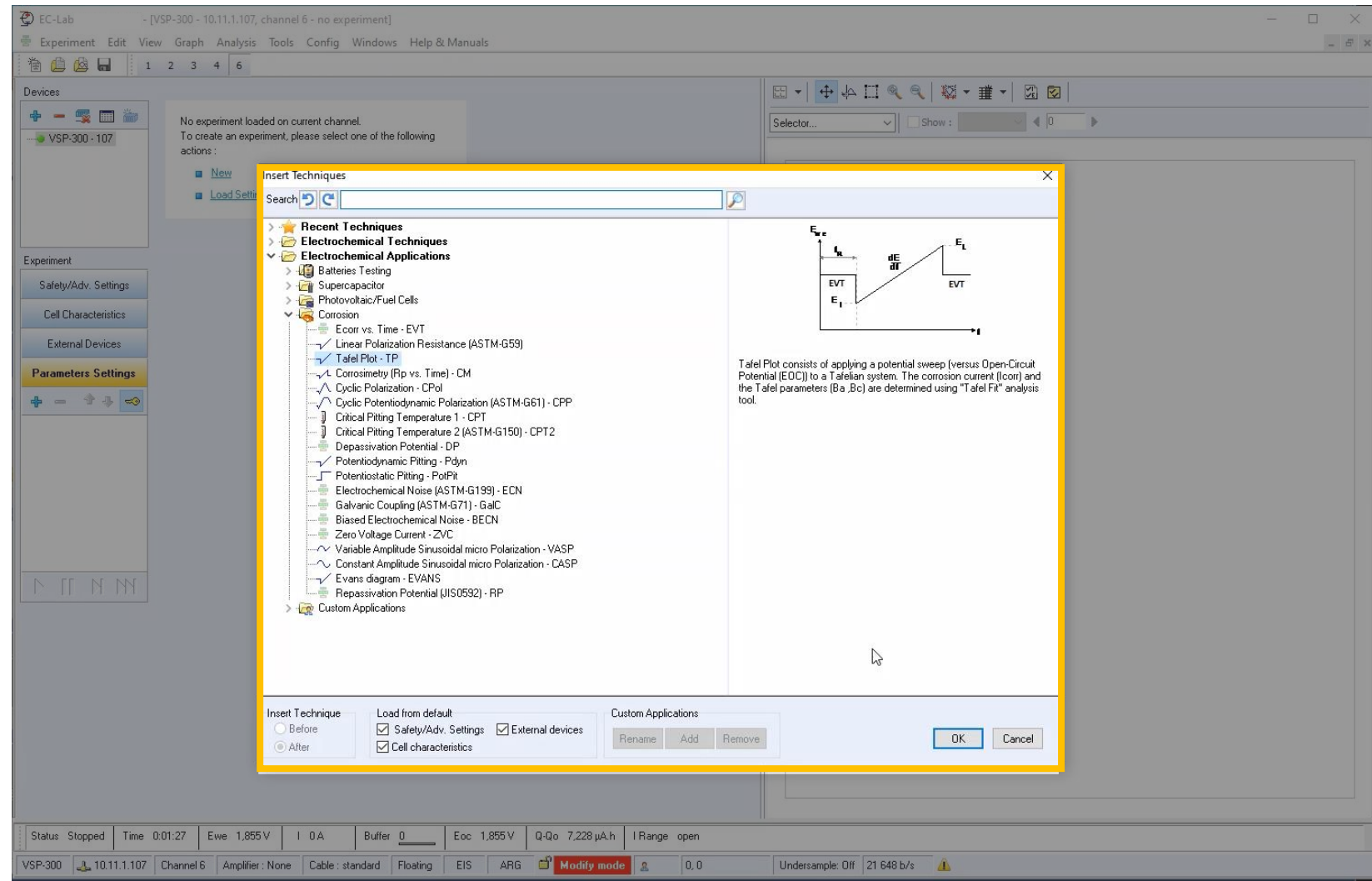


- To move technique before/after



Step 1: Add Tafel Plot technique

- Select Tafel plot technique
It is in the Corrosion folder
- Click on OK to validate





Step 1: Add Tafel Plot technique

Search bar
to quickly find the
desired technique

Description of the
settings technique
and associated graph

EC-Lab - [VSP-300 - 10.11.1.107, channel 6 - no experiment]

Experiment Edit View Graph Analysis Tools Config Windows Help & Manuals

Devices

- VSP-300 - 107

Experiment

- Safety/Adv. Settings
- Cell Characteristics
- External Devices
- Parameters Settings

Insert Techniques

Search

Recent Techniques

- Electrochemical Techniques
- Electrochemical Applications
- Batteries Testing
- Supercapacitor
- Photovoltaic/Fuel Cells
- Corrosion
- Custom Applications

Tafel Plot - TP

Tafel Plot consists of applying a potential sweep (versus Open-Circuit Potential (E_{OC})) to a Tafelian system. The corrosion current (I_{corr}) and the Tafel parameters (B_a, B_c) are determined using "Tafel Fit" analysis tool.

Insert Technique

Load from default

- ☒ Safety/Adv. Settings
- ☒ External devices
- ☒ Cell characteristics

Custom Applications

Rename Add Remove

OK Cancel

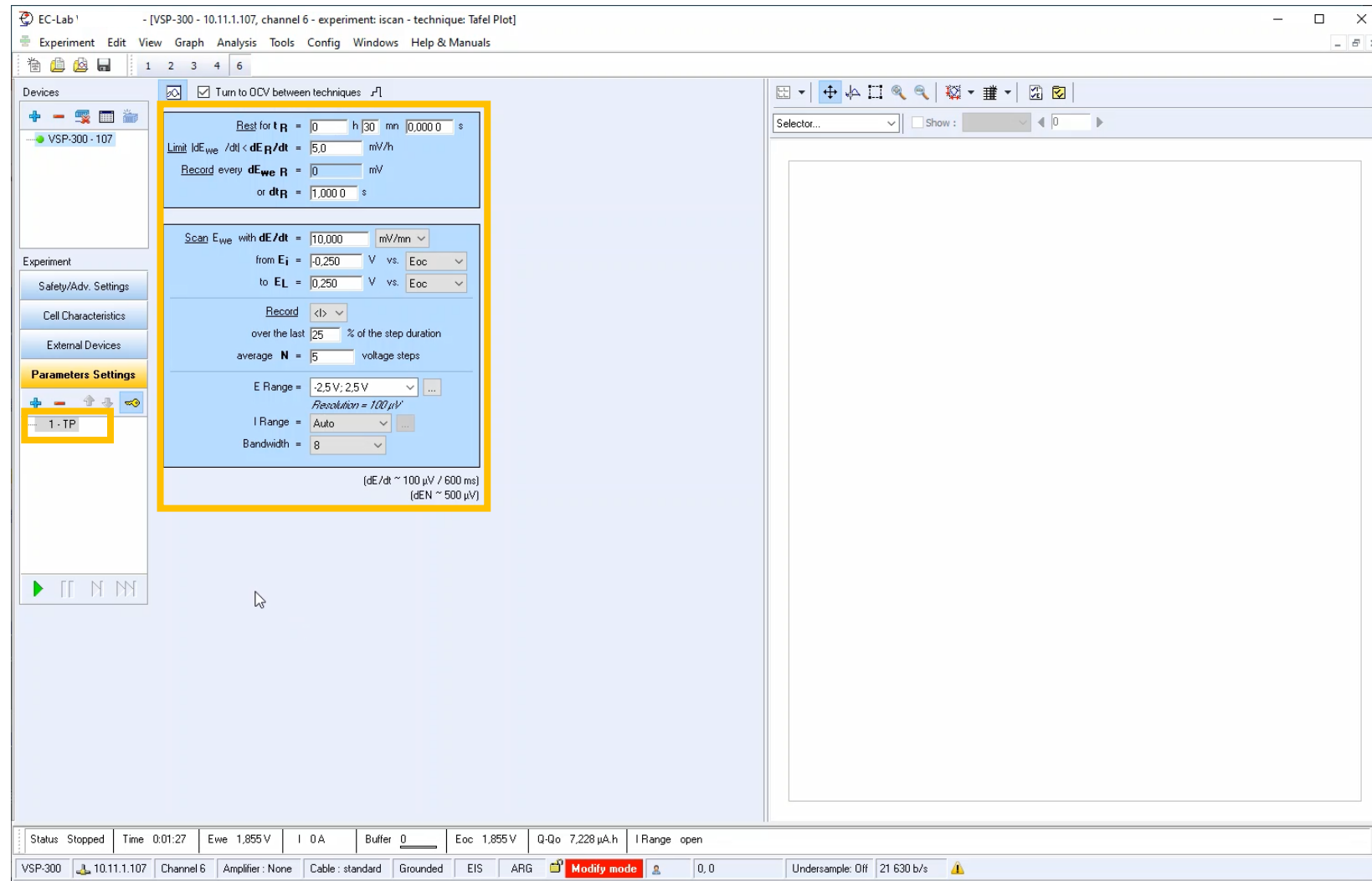
Status Stopped Time 0:01:27 Ewe 1.855 V I 0 A Buffer 0 Eoc 1.855 V Q-Qo 7.228 µA.h I Range open

VSP-300 10.11.1.107 Channel 6 Amplifier: None Cable: standard Floating EIS ARG Modify mode 0, 0 Undersample: Off 21 648 b/s



Step 1: Add Tafel Plot technique

- Tafel Plot technique is loaded in the technique list
- Corresponding Tafel Plot parameter settings appear





Step 1: Add Tafel Plot technique

General parameters

Technique parameters


EC-Lab
VSP-300 - 10.11.1.107, channel 6 - experiment: iscan - technique: Tafel Plot

Experiment Edit View Graph Analysis Tools Config Windows Help & Manuals

1 2 3 4 6

Devices
+ - VSP-300-107

Experiment
Safety/Adv. Settings
Cell Characteristics
External Devices
Parameters Settings
1-TP

Turn to DCV between technique 

Rest for t_R = 0 h 30 mn 0.000 0 s
Limit $|dE_{we}/dt| < dE_R/dt$ = 5.0 mV/h
Record every dE_{we} R = 0 mV
or dt_R = 1.000 0 s


Scan E_{we} with dE/dt = 10.000 mV/min
from E_i = -0.250 V vs. Eoc
to E_L = 0.250 V vs. Eoc

Record <D>
over the last 25 % of the step duration
average N = 5 voltage steps

E Range = -2.5 V; 2.5 V
Resolution = 100 μ V
I Range = Auto
Bandwidth = 8

($dE/dt \sim 100 \mu$ V / 600 ms)
($dEN \sim 500 \mu$ V)

Selector... Show: 0

You can display the description of the settings by clicking on the  icon.





Step 2: Set Tafel Plot parameters

- Set t_R to obtain EVT

Rest for t_R = 0 h 30 mn 0,000 0 s
Limit $|dE_{we} / dt| < dE_R / dt$ = 5,0 mV/h
Record every $dE_{we} R$ = 0 mV
or dt_R = 1,000 0 s

Scan E_{we} with dE/dt = 10,000 mV/mn
from E_i = -0,250 V vs. E_{oc}
to E_L = 0,250 V vs. E_{oc}

Record $\langle I \rangle$
over the last 25 % of the step duration
average N = 5 voltage steps

E Range = -2,5 V; 2,5 V
Resolution = 100 μV
I Range = Auto
Bandwidth = 8

($dE/dt \sim 100 \mu V / 600 ms$)
($dEN \sim 500 \mu V$)

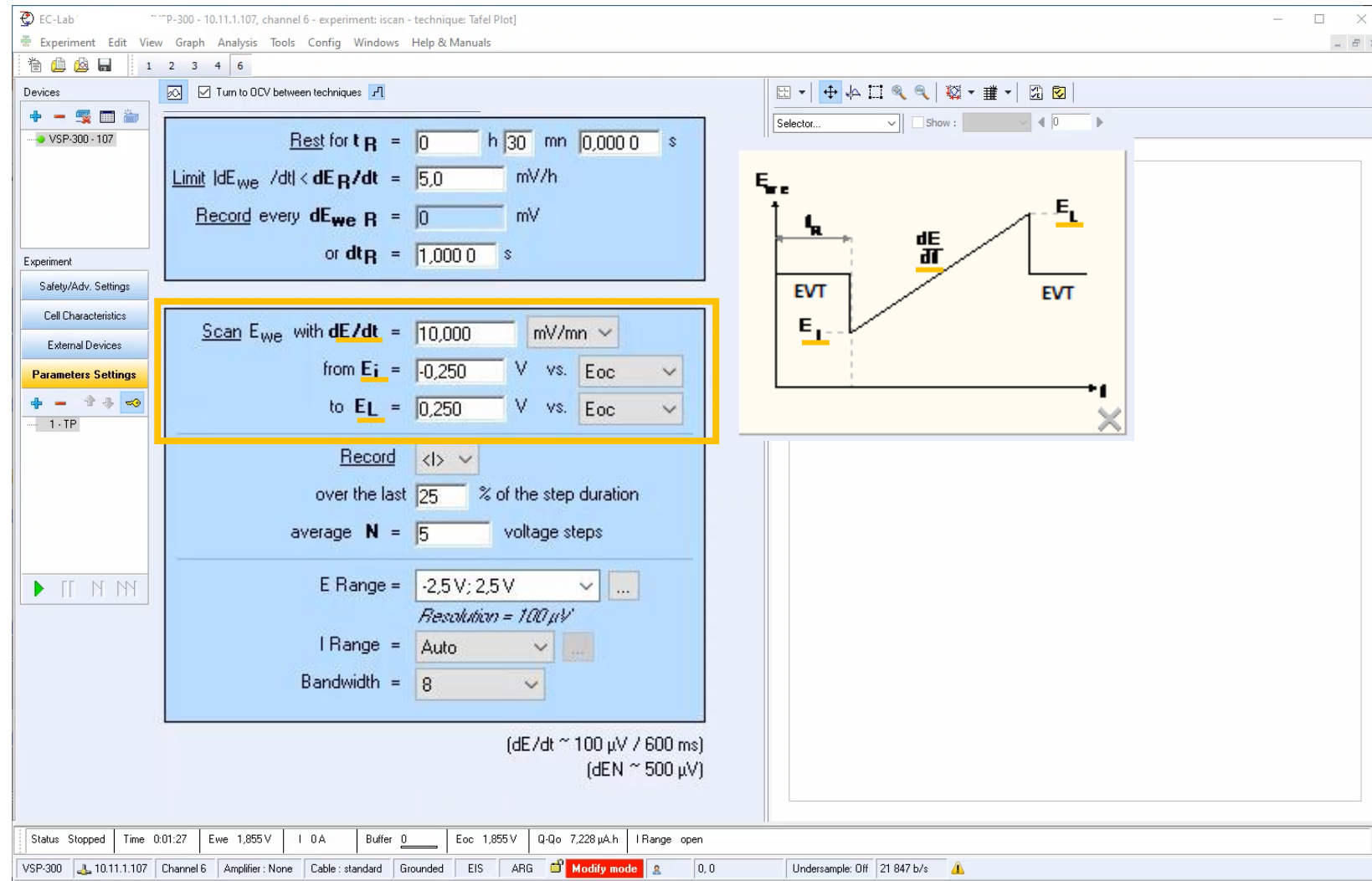
Status Stopped Time 0:01:27 Ewe 1,855 V I 0 A Buffer 0 Eoc 1,855 V Q-Qo 7,228 $\mu A.h$ I Range open
VSP-300 10.11.1.107 Channel 6 Amplifier: None Cable: standard Grounded EIS ARG Modify mode 0,0 Undersample: Off 21 847 b/s

Note: Set limit in time or until stabilization of voltage



Step 2: Set Tafel Plot parameters

- Set E_i and E_L to define voltage ramp
- Set dE/dt to define voltage sweep





Step 2: Set Tafel Plot parameters

Define E_i , E_L versus voltage of:

- **Ref**: the reference electrode
- **Eoc**: open circuit voltage
- **Ectrl**: the previous controlled voltage, if a technique is set before the Tafel plot
- **Emeas**: the previous measured voltage, if a technique is set before the Tafel plot

Rest for t_R = 0 h 30 mn 0,000 0 s
Limit $|dE_{we}/dt| < dE_R/dt$ = 5,0 mV/h
Record every dE_{we} R = 0 mV
or dt_R = 1,000 0 s

Scan E_{we} with dE/dt = 10,000 mV/mn
from E_i = -0,250 V vs. Eoc
to E_L = 0,250 V vs. Eoc

Record <I>
over the last 25 % of the step duration
average N = 5 voltage steps

E Range = -2,5 V; 2,5 V
Resolution = 100 μ V
 I Range = Auto
Bandwidth = 8

($dE/dt \sim 100 \mu V / 600 ms$)
($dEN \sim 500 \mu V$)

vs. Eoc
Ref
Eoc
Ectrl
Emeas



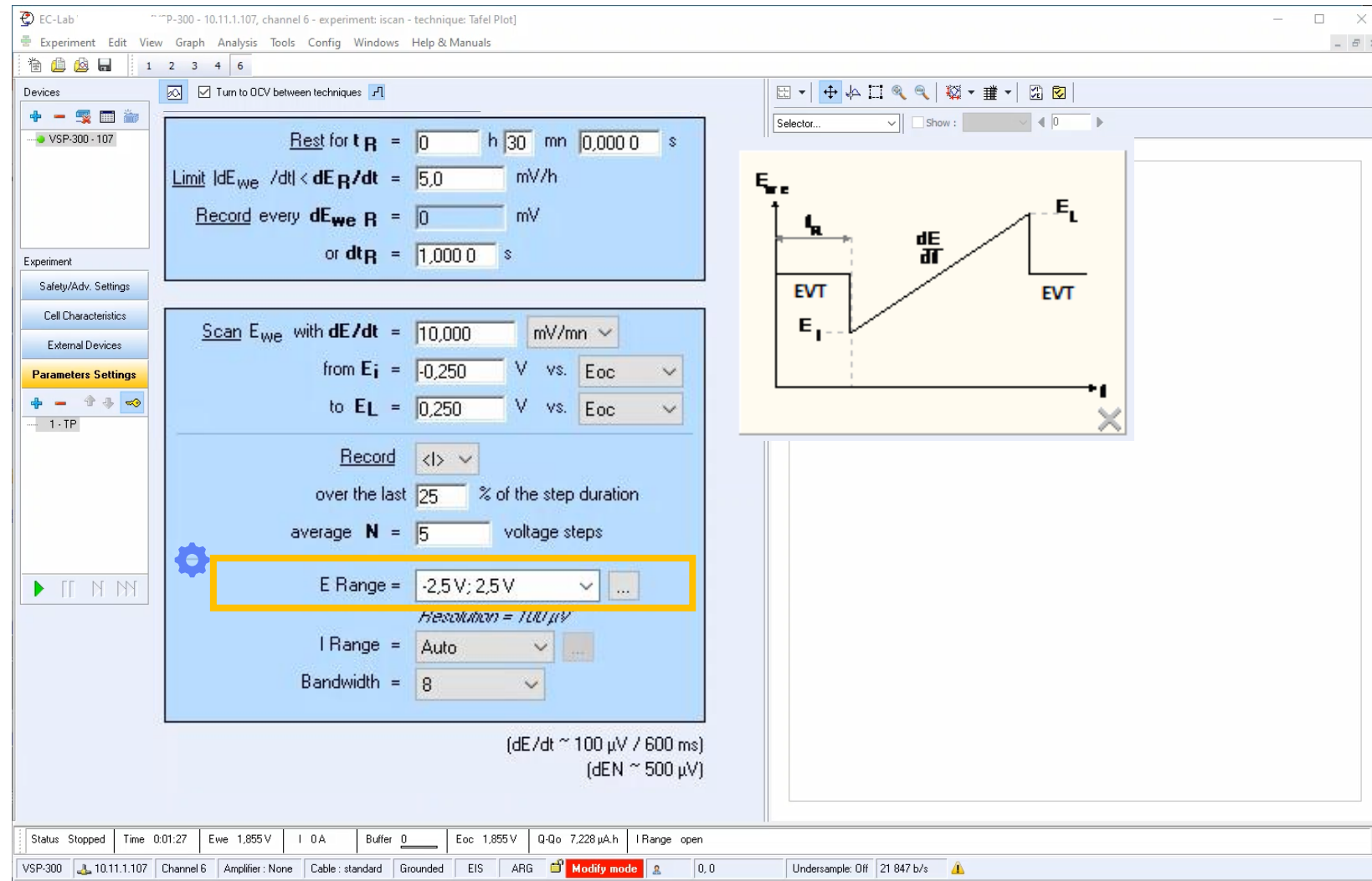
Set E_i and E_L vs. Eoc to polarize from corrosion potential (EVT).



Step 3: Optimize the measurement

- E Range is the range of expected voltage
- E_i and E_L have to be in the E Range

⚙️ E Range has to be as narrow as possible, the resolution depends on it.

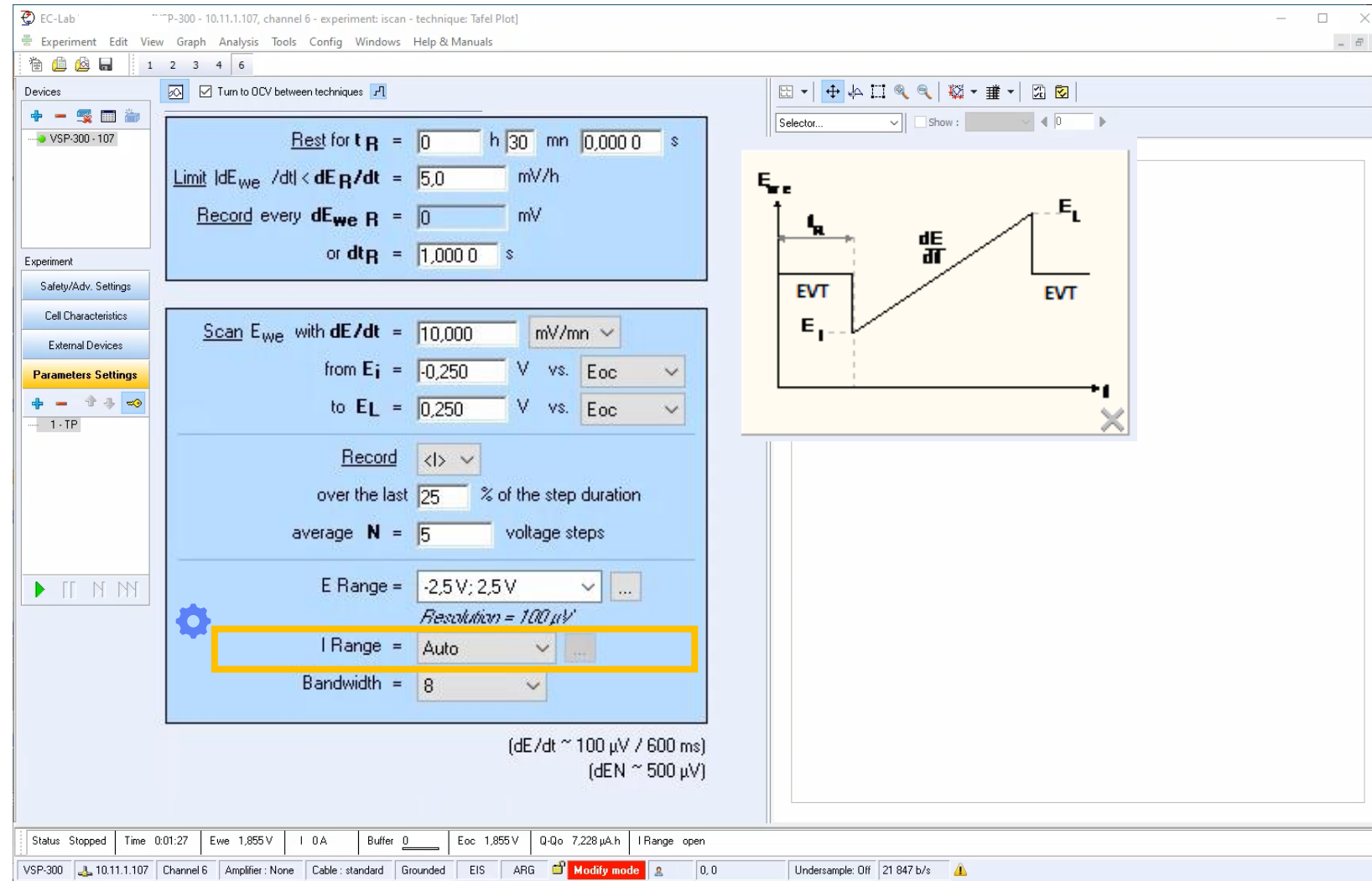




Step 3: Optimize the measurement

- I Range is the range of expected current
- Autorange is available

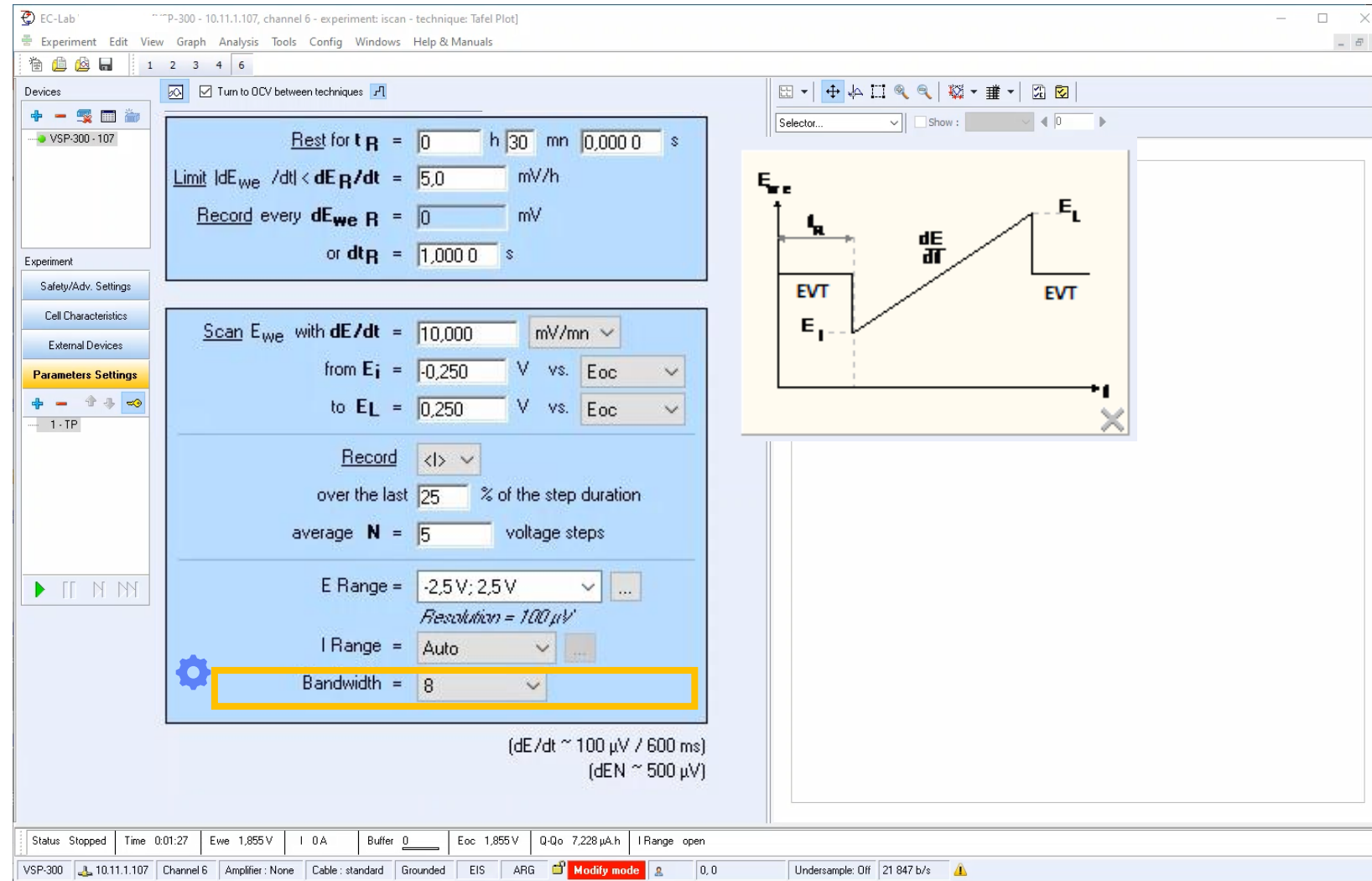
⚙️ Autorange is recommended when current range is unknown.





Step 3: Optimize the measurement

- Adjust bandwidth to make sure that the potentiostat controls the cell in stable and fast way



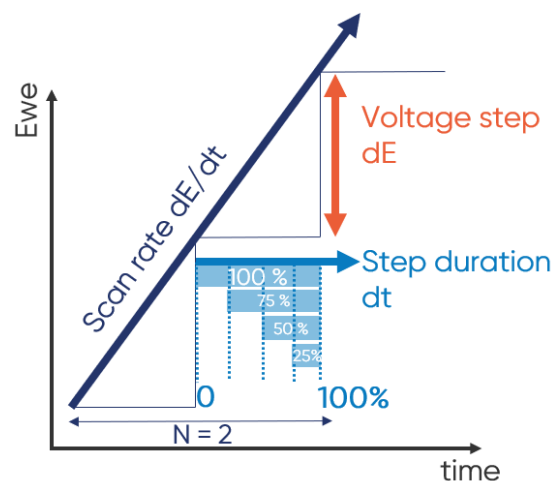
⚙️ Set medium bandwidth to start

- 8-medium for essential
- 5-medium for premium



Step 3: Optimize the measurement

- Adjust current averaging and measurement



Note: dE is dependent on potential resolution

- Set to 25% to cut first current value points and mainly measured Faradaic current.

$N = 5$ voltage steps allows to get smoother data

The screenshot shows the EC-Lab software interface for a Tafel Plot experiment. The main window displays the following parameters:

- Rest for t_R** : 0 h 30 mn 0,000 0 s
- Limit $|dE_{we}/dt| < dE_R/dt$** : 5,0 mV/h
- Record every $dE_{we} R$** : 0 mV
- or dt_R** : 1,000 0 s
- Scan E_{we} with dE/dt** : 10,000 mV/mn
- from E_i** : -0,250 V vs. E_{oc}
- to E_L** : 0,250 V vs. E_{oc}
- Record**: $\langle I \rangle$
- over the last**: 25 % of the step duration
- average N** : 5 voltage steps
- E Range**: -2,5 V; 2,5 V
- Resolution**: 100 μV
- I Range**: Auto
- Bandwidth**: 8

At the bottom right, the scan rate is specified as $(dE/dt \sim 100 \mu V / 600 \text{ ms})$ and $(dEN \sim 500 \mu V)$.

The status bar at the bottom shows: Status Stopped, Time 0:01:27, E_{we} 1,855 V, I 0 A, Buffer 0, E_{oc} 1,855 V, $Q-Q_0$ 7,228 $\mu A \cdot h$, I Range open.



Step 4: Set general parameters

- Add information and comments about the cell

EC-Lab V1 [VSP-300 - 10.11.1.107, channel 6 - experiment: iscan - technique: Tafel Plot]

Experiment Edit View Graph Analysis Tools Config Windows Help & Manuals

1 2 3 4 6

Devices

- VSP-300 - 107

Experiment

- Safety/Adv. Settings
- Cell Characteristics**
- External Devices
- Parameters Settings

1 - TP

Cell Description

Electrode material

Initial state

Electrolyte

Comments

Electrode surface area (A) 0,001 cm²

Characteristic mass 0,001 g

Volume (V) 0,001 cm³

Battery Corrosion **Materials**

Equivalent Weight 0,000 g/eq

Density 0,000 g/cm³

Reference Electrode

(unspecified)

Offset potential vs. Normal Hydrogen Electrode: 0,000 V

Status: Stopped Time: 0:01:27 Ewe: 1,855 V I: 0 A Buffer: 0 Eoc: 1,855 V Q-Qo: 7,228 µA.h I Range: open

VSP-300 10.11.1.107 Channel 6 Amplifier: None Cable: standard Grounded EIS ARG Modify mode 0, 0 Undersample: Off 21 523 b/s

Note: All this information is store in the data file



Step 4: Set general parameters

Dedicated corrosion section
(Save your sample characteristics in a template)

Values are used for Tafel fit analysis

EC-Lab V1 - VSP-300 - 10.11.1.107, channel 6 - experiment: iscan - technique: Tafel Plot]

Experiment Edit View Graph Analysis Tools Config Windows Help & Manuals

1 2 3 4 6

Devices

- VSP-300-107

Experiment

- Safety/Adv. Settings
- Cell Characteristics**
- External Devices
- Parameters Settings
- 1-TP

Cell Description

Electrode material

Initial state

Electrolyte

Comments

Electrode surface area (A) 0,001 cm²

Characteristic mass 0,001 g

Volume (V) 0,001 cm³

Battery Corrosion Materials

Equivalent Weight 0,000 g/eq

Density 0,000 g/cm³

Reference Electrode (unspecified)

Offset potential vs. Normal Hydrogen Electrode: 0,000 V

Cell Characteristics

Template

Battery

- Li2FeSiO4 18650
- Li2FeSiO4 26650
- Li2FeSiO4 coinell
- LiCoO2 18650
- LiCoO2 26650
- LiCoO2 coinell
- LiFeBO3 18650
- LiFeBO3 26650
- LiFeBO3 coinell
- LiFePO4 18650
- LiFePO4 26650
- LiFePO4 coinell
- LiFePO4F 18650
- LiFePO4F 26650
- LiFeSO4F 18650
- LiFeSO4F 26650
- LiMn2O4 18650
- LiMn2O4 26650

Corrosion

- Al
- Fe**
- Ni
- SS304
- SS316

Materials

- CESH ID100
- CESH ID250
- CESH TP 1
- CESH TP 1 Guard
- CESH TP 2
- CESH TP 2 Guard
- CESH TP 20
- CESH TP 20 Guard
- HTTC

Name Fe

Cell Description

Electrode material Iron

Initial state

Electrolyte

Comments

Electrode surface area (A) 1,000 cm²

Characteristic mass 100,000 mg

Volume (V) 0,001 cm³

Battery Corrosion Materials

Equivalent Weight 27,920 g/eq

Density 7,874 g/cm³

Select Cancel

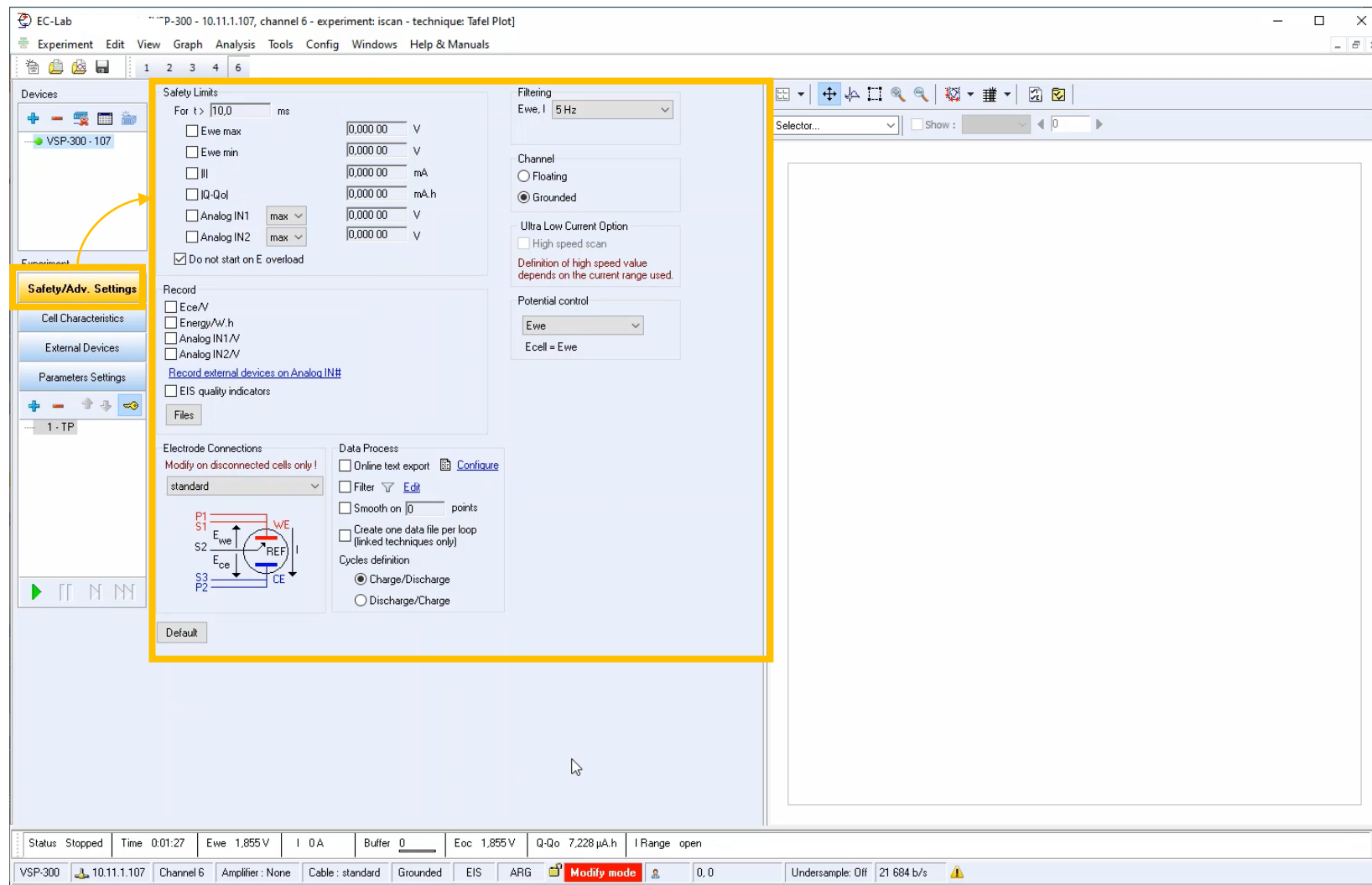
Status Stopped Time 0:01:27 Ewe 1,855 V I 0 A Buffer 0 Eoc 1,855 V Q-Qo 7,228 µA.h I Range open

VSP-300 10.11.1.107 Channel 6 Amplifier: None Cable: standard Grounded EIS ARG Modify mode 0, 0 Undersample: Off 21 523 b/s



Step 4: Set general parameters

- Safety and Advanced Settings are available here



Note: This windows is different for the Essential and Premium instruments

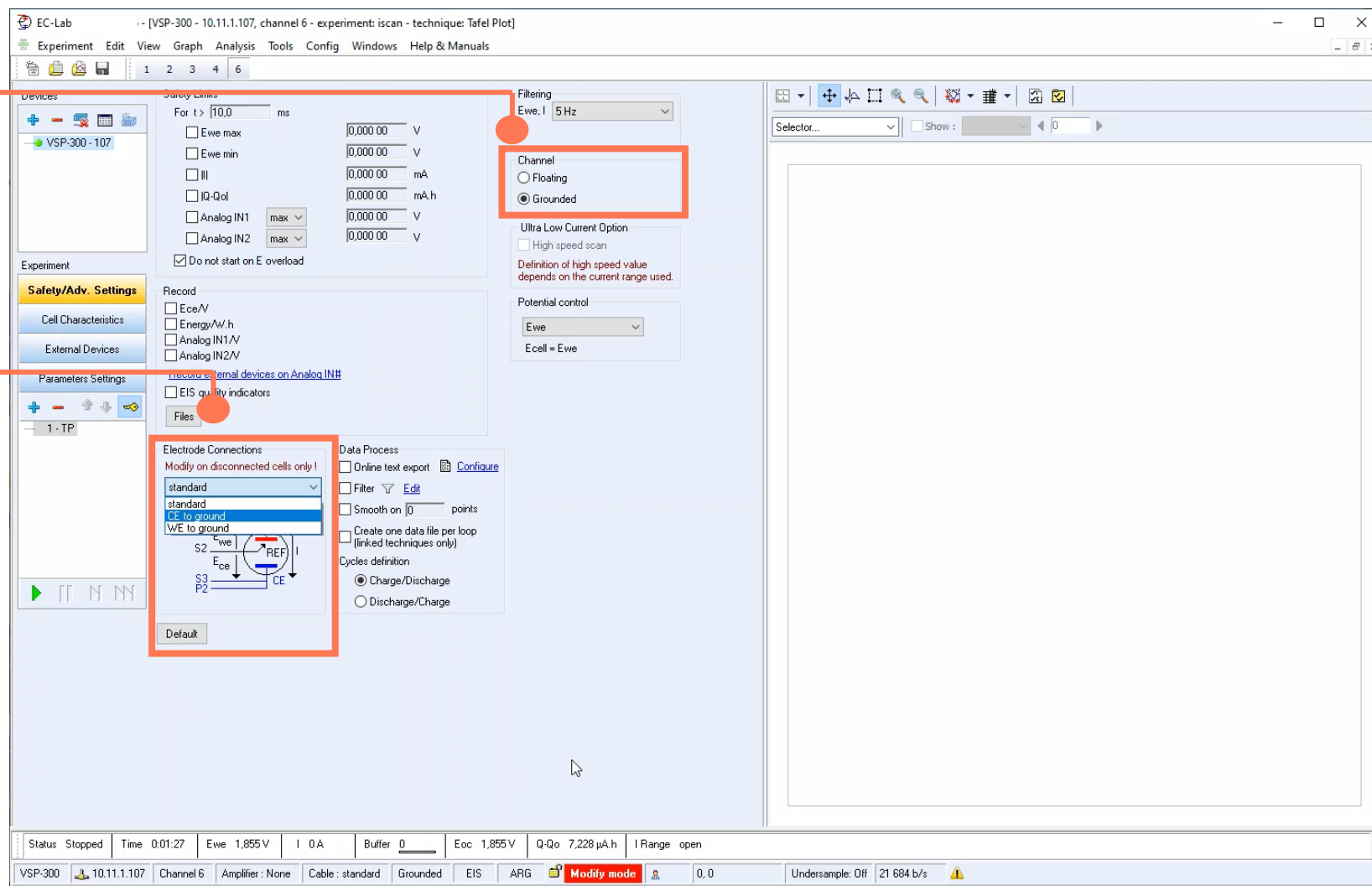


Step 4: Set general parameters

Floating connection

avoid ground loop
(only available for
Premium potentiostats)

CE to ground enable
multielectrode
experiments





Step 5: Launch the measurement

- Click on ▶ to launch experiment

EC-Lab [VSP-300 - 10.11.1.107, channel 6 - experiment: iscan - technique: Tafel Plot]

Experiment Edit View Graph Analysis Tools Config Windows Help & Manuals

1 2 3 4 6

Devices

- VSP-300-107

Experiment

- Safety/Adv. Settings
- Cell Characteristics
- External Devices
- Parameters Settings**

1-TP

Turn to DCV between techniques

Rest for t_R = 0 h 30 min 0.000 0 s

Limit $|dE_{we}/dt| < dE_R/dt$ = 5.0 mV/h

Record every dE_{we} R = 0 mV

or dt_R = 1,000 0 s

Scan E_{we} with dE/dt = 10,000 mV/min

from E_i = -0.250 V vs. Eoc

to E_L = 0.250 V vs. Eoc

Record <D>

over the last 25 % of the step duration

average N = 5 voltage steps

E Range = -2.5 V; 2.5 V

Resolution = 100 μ V

I Range = Auto

Bandwidth = 8

($dE/dt \sim 100 \mu$ V / 600 ms)

($dEN \sim 500 \mu$ V)

Selector...

Show : 0

Status Stopped Time 0:01:27 Ewe 1,855 V I 0 A Buffer 0 Eoc 1,855 V Q-Qo 7,228 μ A.h I Range open

VSP-300 10.11.1.107 Channel 6 Amplifier: None Cable: standard Grounded EIS ARG Modify mode 0, 0 Undersample: Off 21 847 b/s

Note: All the settings may be changed during the experiment (Modify on the fly) except I range, E range and bandwidth



Step 5: Launch the measurement

Load techniques with same settings using a .mps file created when launching the experiment

Status of experiment is displayed (Stopped, Paused, Relax...)

The screenshot displays the EC-Lab software interface. The top menu bar includes 'Experiment', 'Edit', 'View', 'Graph', 'Analysis', 'Tools', 'Config', 'Windows', and 'Help & Manuals'. The 'Experiment' menu is open, showing options like 'Turn to DCV between techniques'. The 'Parameters Settings' panel on the left is active, showing '1-TP' settings. The main panel displays 'Rest for t_R = 0 h 30 min 0.000 0 s', 'Limit |dE_{we}/dt| < dE_R/dt = 5.0 mV/h', 'Record every dE_{we} R = 0 nV or dt_R = 1,000 0 s', 'Scan E_{we} with dE/dt = 10,000 mV/min', 'from E_i = -0.250 V vs. E_{oc}', 'to E_L = 0.250 V vs. E_{oc}', 'Record <D>', 'over the last 25 % of the step duration', 'average N = 5 voltage steps', 'E Range = -2.5 V; 2.5 V', 'Resolution = 100 μV', 'I Range = Auto', and 'Bandwidth = 8'. A small graph shows a potential scan. The status bar at the bottom indicates 'Status Stopped', 'Time 0:01:27', 'Ewe 1.855 V', 'I 0 A', 'Buffer 0', 'Eoc 1.855 V', 'Q-Qo 7.228 μA.h', 'I Range open', 'VSP-300', '10.11.1.107', 'Channel 6', 'Amplifier: None', 'Cable: standard', 'Grounded', 'EIS', 'ARG', 'Modify mode', '0,0', and 'Undersample On 21.847 b/s'. A red box highlights the 'Status Stopped' text. A red box highlights the 'Next technique' and 'Next sequence' buttons. A red box highlights the 'Stop experiment' and 'Pause experiment' buttons. A red box highlights the 'Next technique' and 'Next sequence' buttons.

Stop experiment

Pause experiment

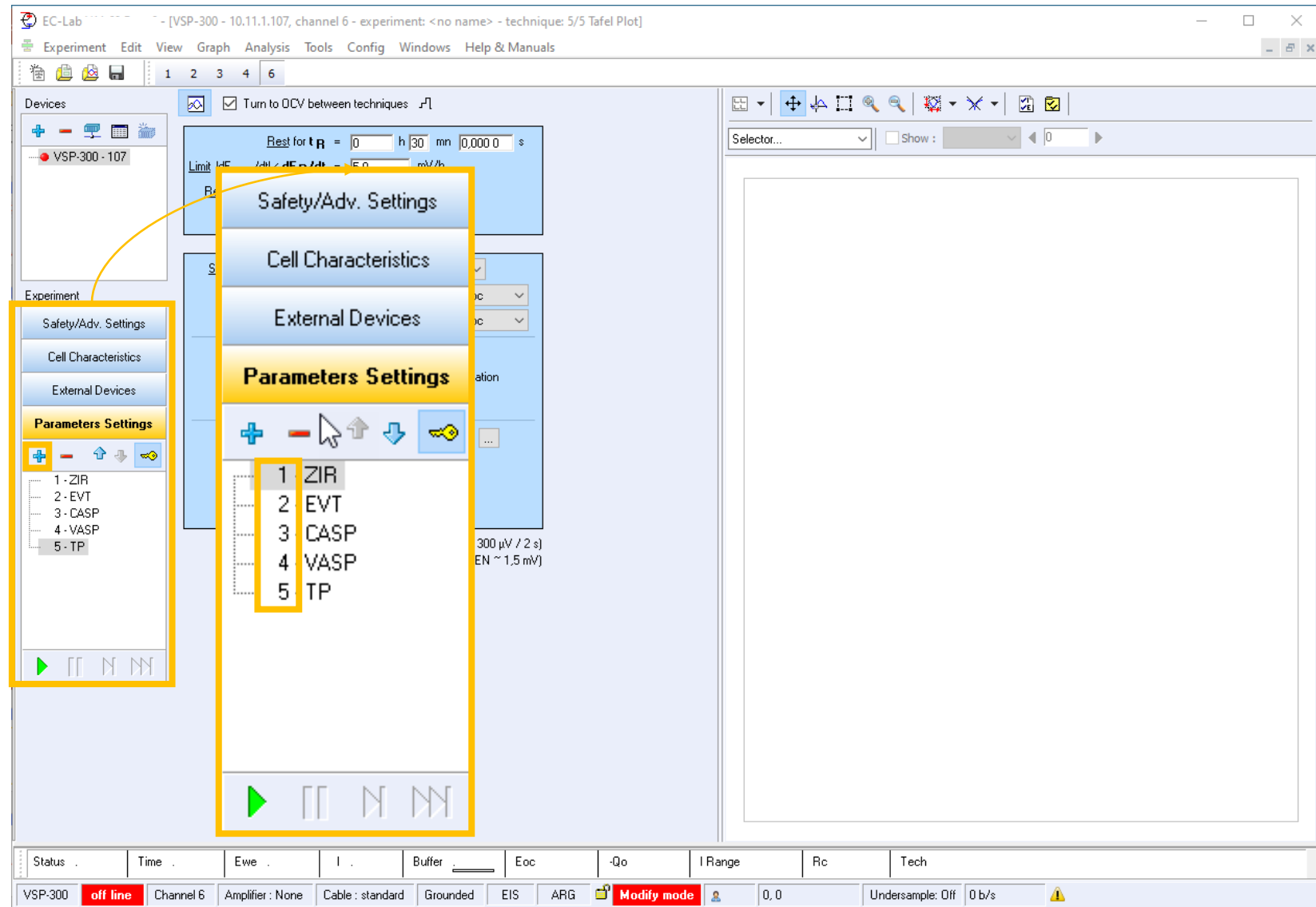
Next technique

Next sequence



Step 6: Add additional experiments

- Click on + button to add more techniques
- Order of execution appears in the technique list





Step 6: Add additional experiments

EC-Lab [VSP-300 - 10.11.1.107, channel 6 - experiment: <no name> - technique: 5/5 Tafel Plot]

Experiment Edit View Graph Analysis Tools Config Windows Help & Manuals

1 2 3 4 6

Devices

VSP-300 - 107

Turn to OCV between techniques

Rest for t_R = 0 h 30 mn 0.000 0 s

Limit $Id_{E_{we}} / dt < dE_R / dt$ = 5.0 mV/h

Record every $dE_{we} R$ = 0 mV

or dt_R = 1.000 0 s

Scan E_{we} with dE/dt = 10.000 mV/mn

from E_i = -0.250 V vs. E_{oc}

to E_L = 0.250 V vs. E_{oc}

Record <I>

over the last 25 % of the step duration

average N = 5 voltage steps

E Range = -10 V; 10 V

Resolution = 333.33 μV

I Range = Auto

Bandwidth = 8

($dE/dt \sim 300 \mu V / 2 s$)
($dEN \sim 1.5 mV$)

Insert Techniques

Search zir

Recent Techniques

- Electrochemical Techniques
 - Voltamperometric Techniques
 - Impedance Spectroscopy
 - Pulsed Techniques
 - Technique Builder
 - Ohmic Drop Determination
 - Manual IR compensation - MIR
 - IR compensation (PEIS) - ZIR
 - Current Interrupt - CI
- Electrochemical Applications

The ohmic drop is defined by the solution resistance between the working electrode and the reference electrode. It is a critical parameter that can be significant when experiments are made in nonaqueous media. It may lead to severe distortion of the voltammetric response. The best way to determine the uncompensated resistance (R_u) is to perform an impedance measurement at high frequencies. The ZIR technique offers the possibility to determine the solution resistance R_u for one high frequency value. The user can select the percentage of compensation. It is highly recommended to not exceed 85% of the R_u measured value in order to avoid oscillations of the instrument.

Insert Technique

Load from default

Before

After

Safety/Adv. Settings

Cell characteristics

External devices

Custom Applications

Rename Add Remove

OK Cancel

Can be used to determine and compensate ohmic drop

1 - ZIR

2 - EVT

3 - CASP

4 - VASP

5 - TP

Impedance techniques must be performed before Tafel Plot

You can save personalized protocols to technique list with **Save As Custom Application...** (in the main bar menu Experiment) and find it under Electrochemical Application - Custom Applications **My protocol - EVT+CASP+VASP+TP**

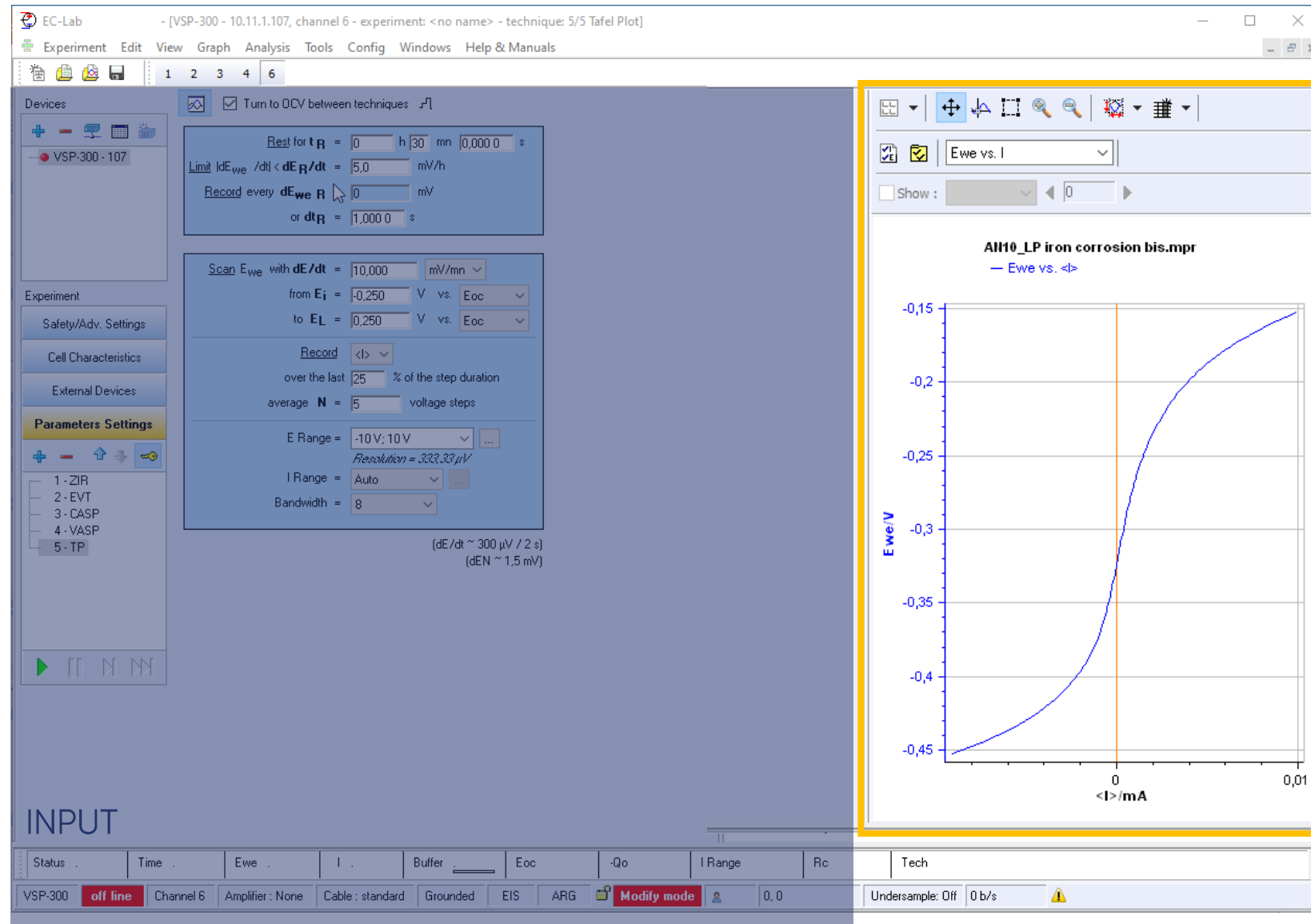
Status Time Ewe I Buffer Eoc -Qo I Range Rc Tech

VSP-300 **off line** Channel 6 Amplifier: None Cable: standard Grounded EIS ARG **Modify mode** 0.0 Undersample: Off 0 b/s



Step 7: Read the graph

- Graphic is displayed in real time
- Data are saved in .mpr file

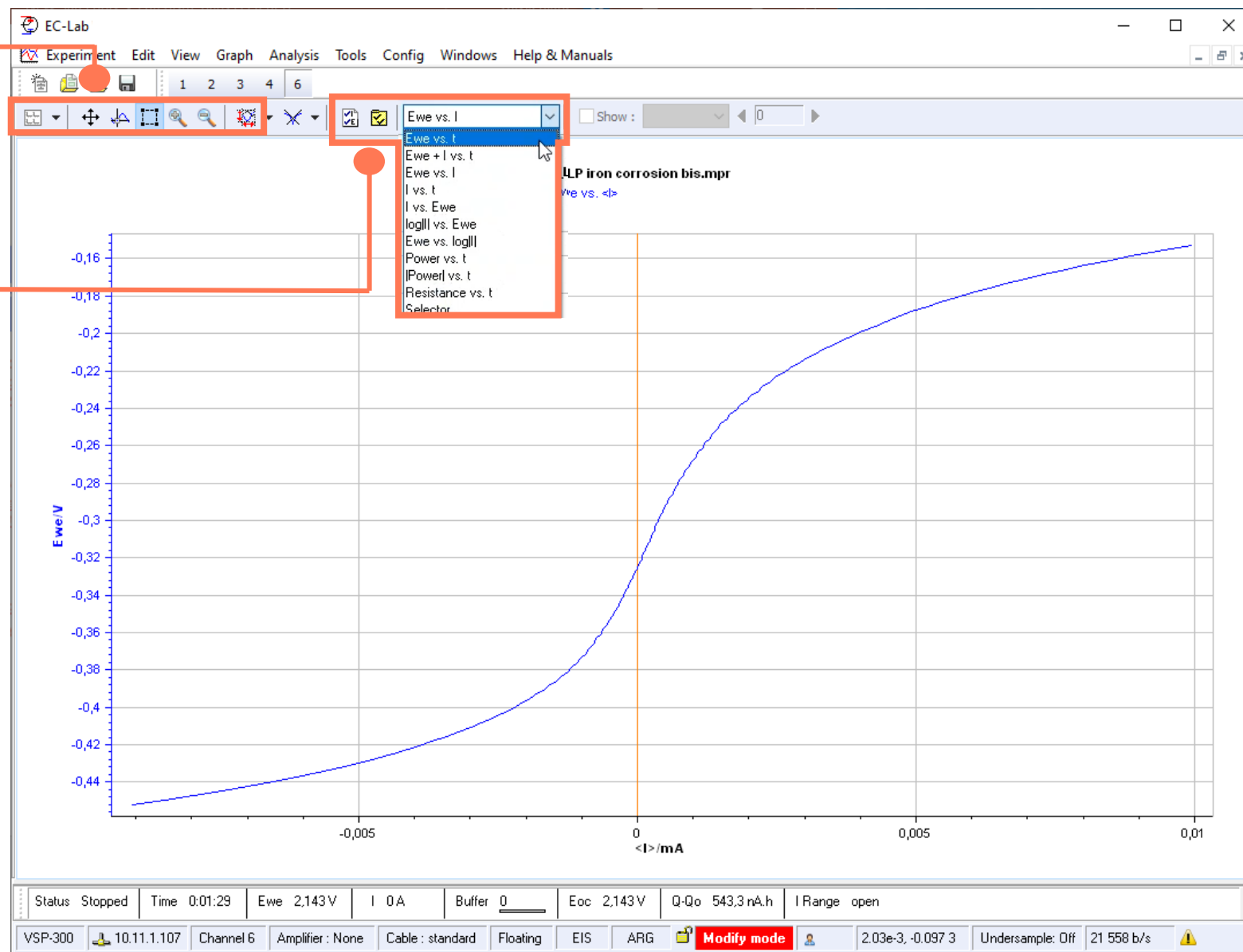




Step 7: Read the graph

Browse through the graph
(Filter, Scroll, Cursor, Selection,
Zoom +, Zoom -, Autoscale)

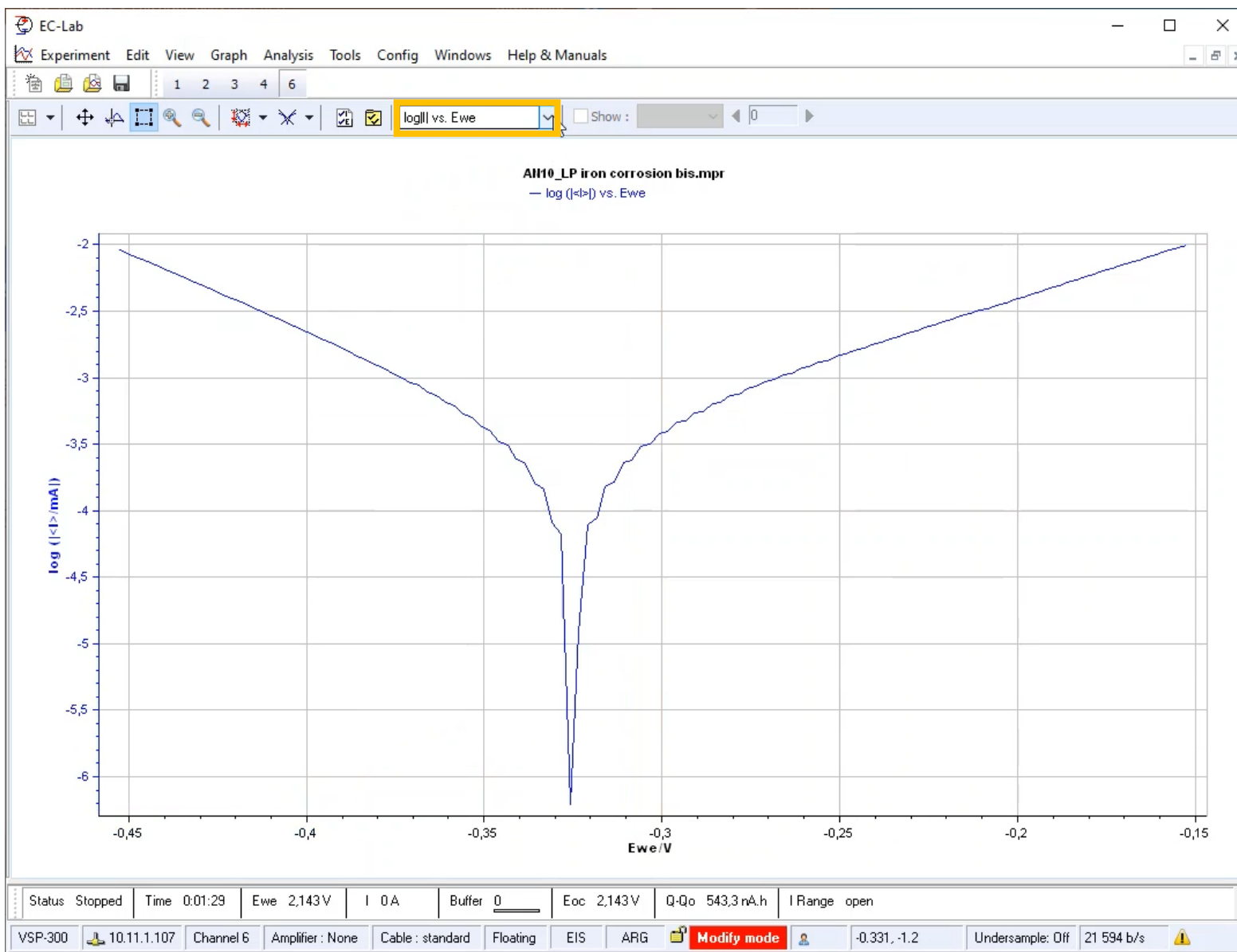
Modify the graph
(Selector, graphic properties,
representations)





Step 8: Analyse the data with Tafel Fit

- Change representation to $\log|i|$ vs. Ewe

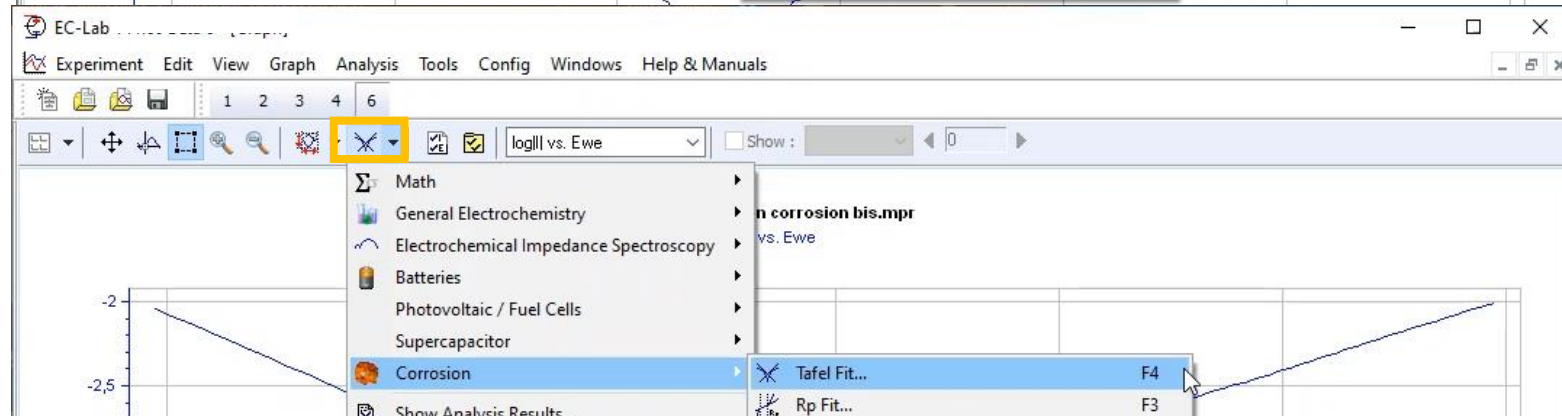
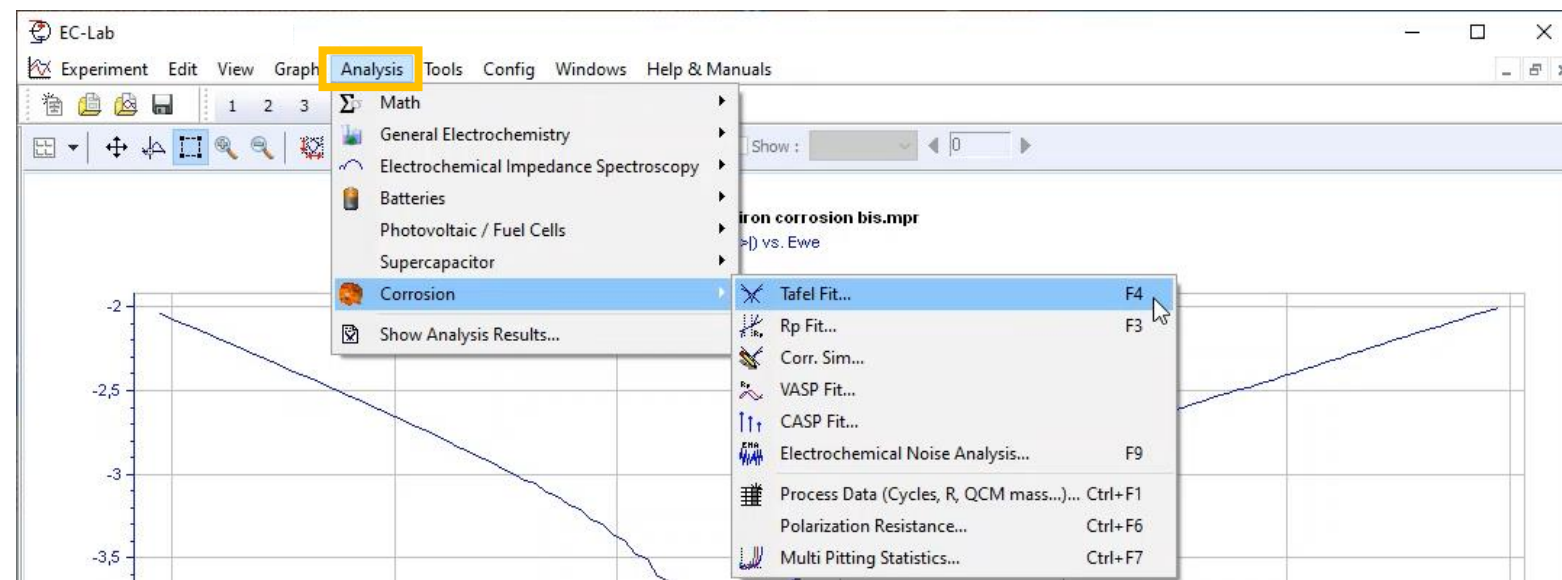




Step 8: Analyse the data with Tafel Fit

- Analyse with Tafel Fit

Note: Analysis is available either in the main tool bar or as a shortcut in the graph bar or with F6

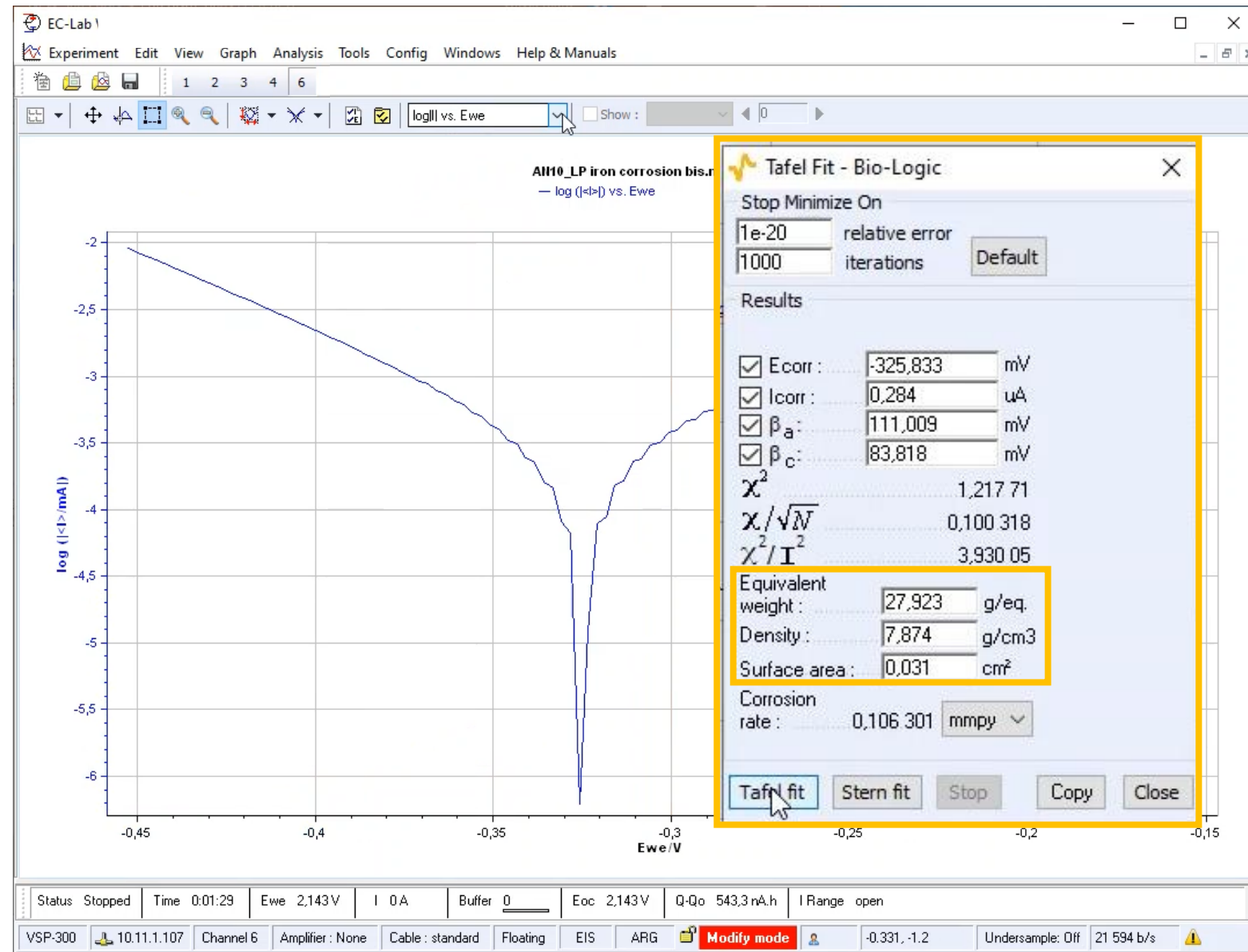


Did you know? Corr Sim (available in Analysis – corrosion) is a powerful corrosion simulation. It can be used as a learning tool.



Step 8: Analyse the data with Tafel Fit

- Set sample values (if not provided before in [cell characteristics](#))

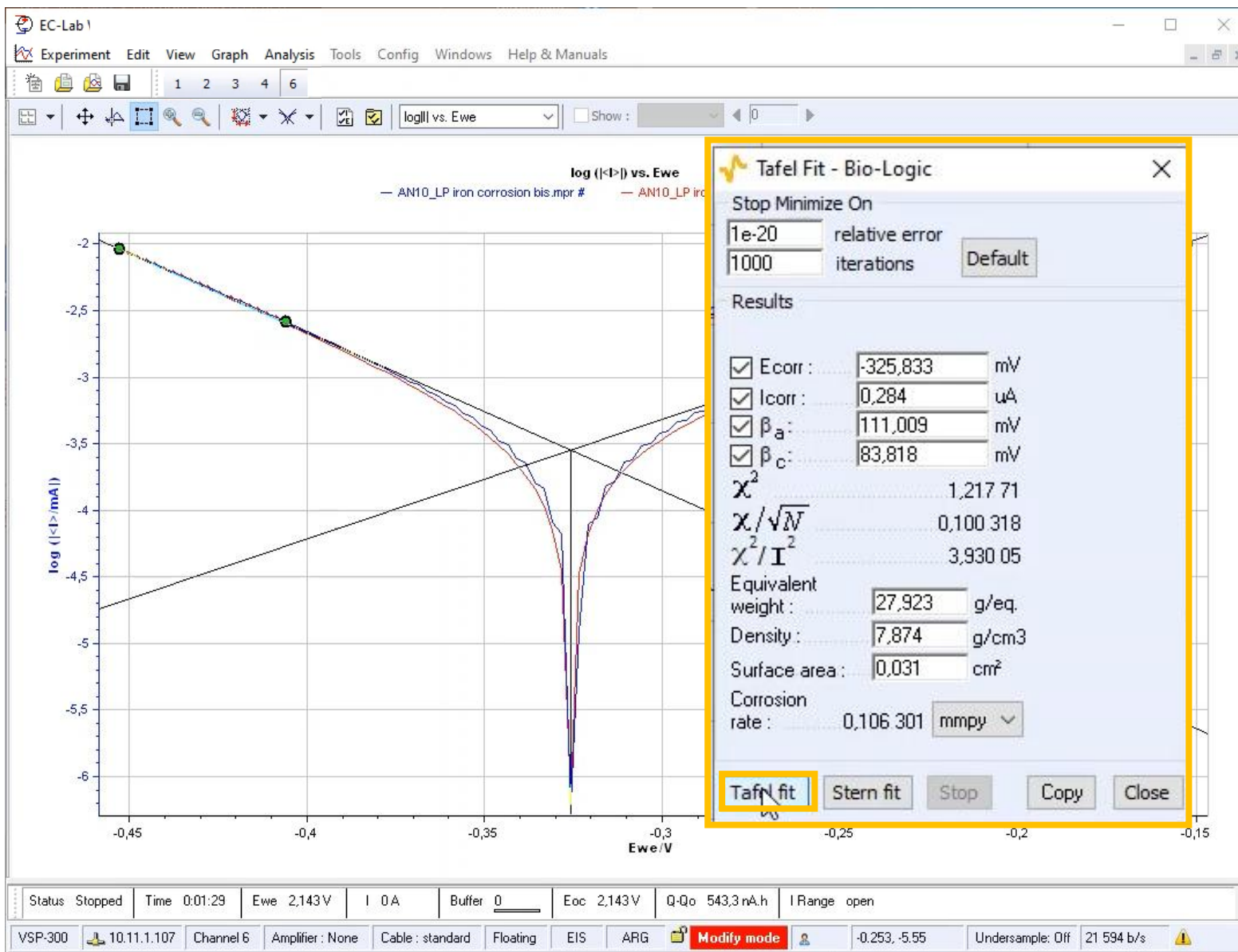




Step 8: Analyse the data with Tafel Fit

- Click on Tafel Fit to calculate

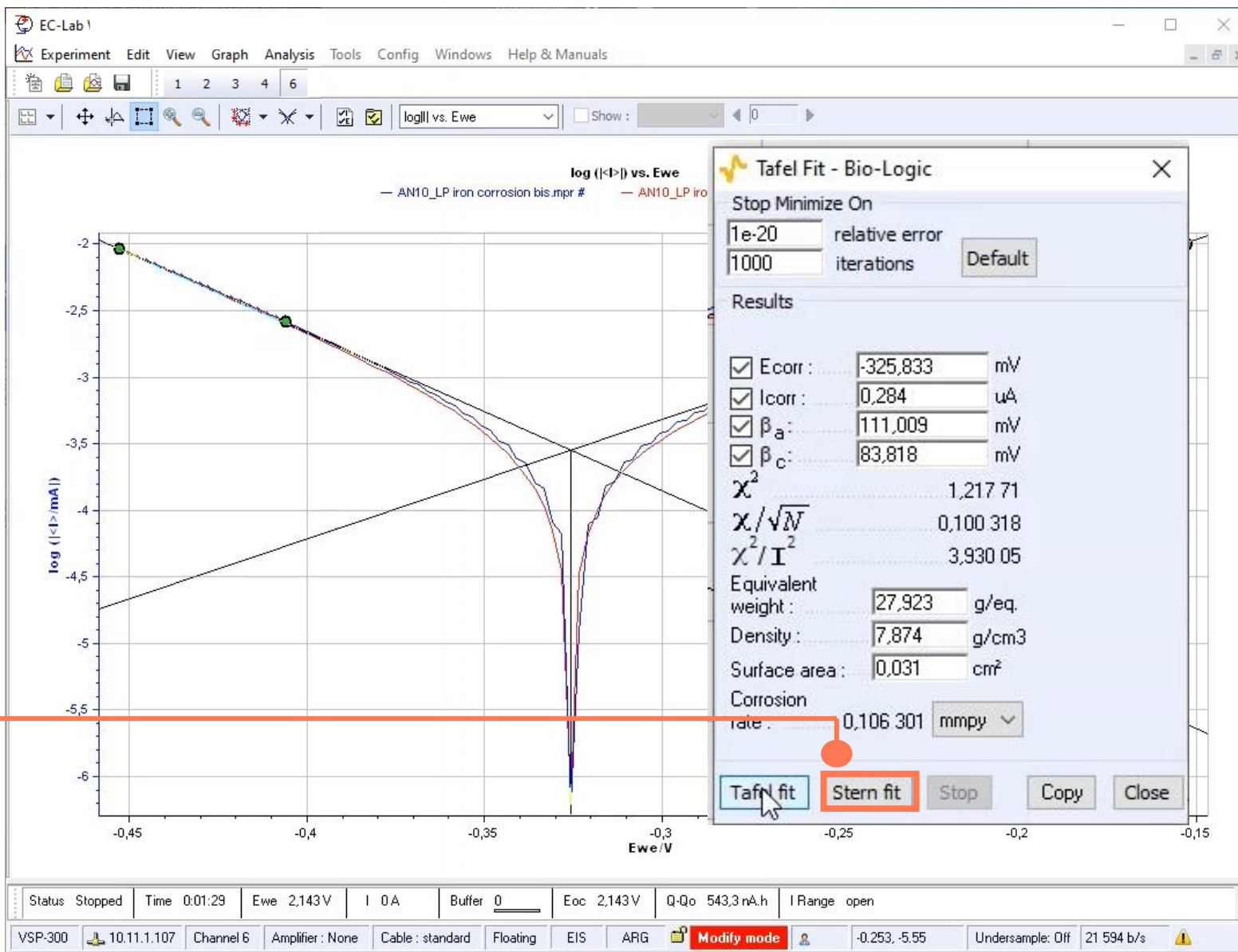
Note: xx_tafel.mpp temporary file is generated. It can be saved as a .mpr file





Step 8: Analyse the data with Tafel Fit

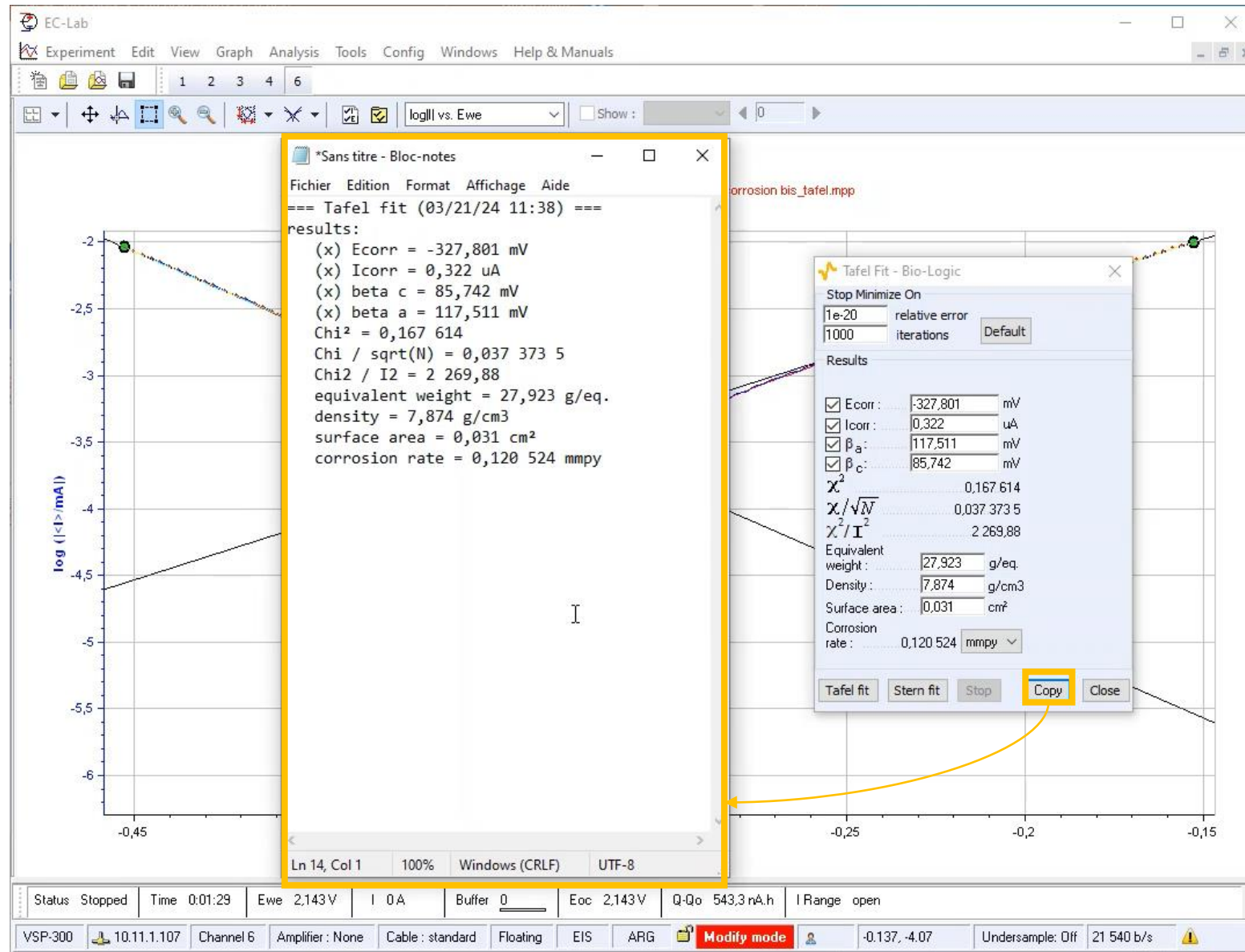
A simulated Tafel graph
can be displayed if
experimental curve is not
« **tafelian enough** »





Step 8: Analyse the data with Tafel Fit

- Save the results with copy/paste



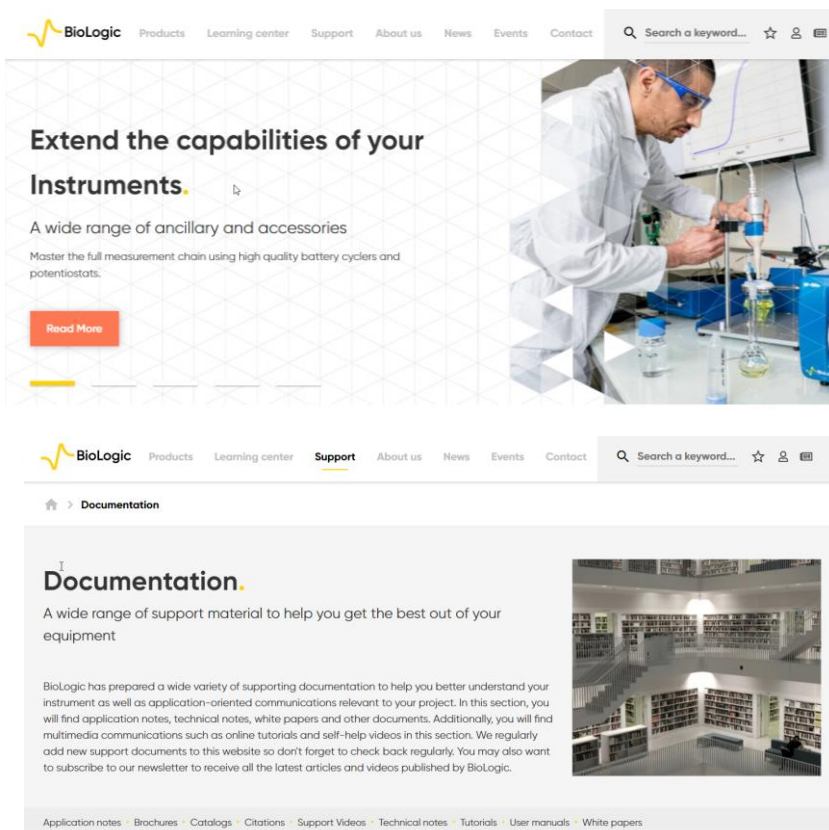


Find out more



For supplementary information

Visit our website!



- Documentation list
 - Corrosion basics (article)
 - Corrosion current measurement (Application Note #10)
 - EC-Lab Techniques and Applications (manual)
 - EC-Lab Analysis and Data Process (manual)



Did you know? Free update of EC-Lab® are available on our website.



Need help?

Contact us!



- Helpful information to provide when contacting support center:
 - Serial number of the instrument (located on the rear panel of the device)
 - Software and hardware version you are currently using (on the Help menu, About on EC-Lab)
 - Operating system on the connected computer
 - Connection mode (Ethernet, LAN, USB) between computer and instrument

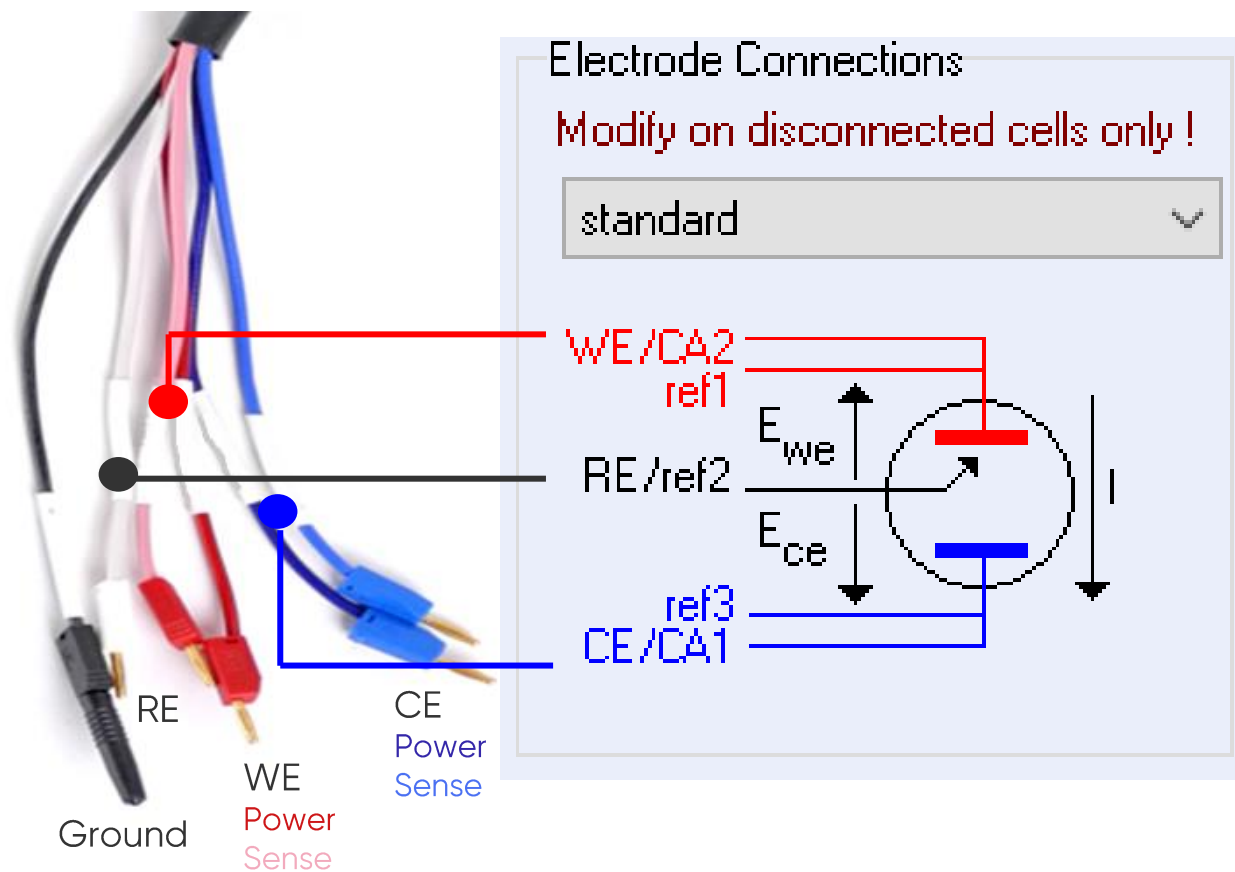


FAQ

- How do I connect potentiostat to the cell?
- When should I use floating mode instead of grounded?
- How to optimize the measurement?
- How do I select correct bandwidth?
- Why should I use Rotating Disk Electrode (RDE) during Tafel Plot experiment?



How do I connect potentiostat to the cell?



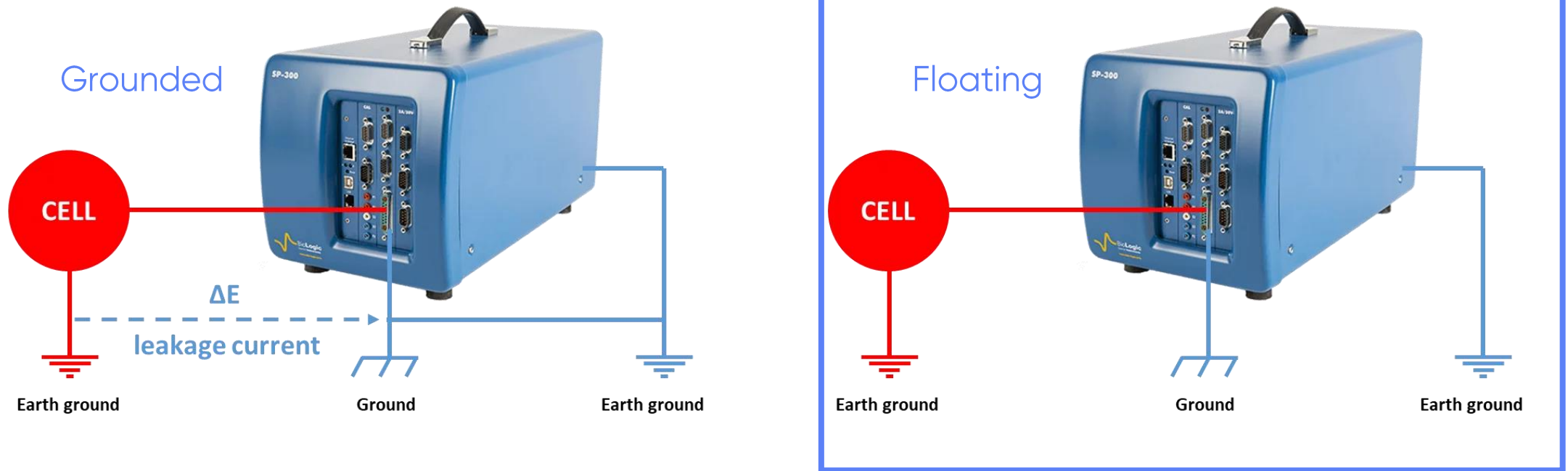
- In standard electrode connections mode:
 - Working Electrode (WE)
Connect power and sense
 - Reference Electrode (RE)
 - Counter Electrode (CE)
Connect power and sense

Note: For other connection modes, refer to Connection to the cell (article) or Technical Notes #09 and #11, or Installation and Configuration Manual.



When should I use floating mode instead of grounded?

- When the cell is directly connected to the earth, the “floating” connection type is generally used to avoid leakage current



Note: For more details, refer to What is ground? (article)



How to optimize the measurement?

- Accuracy of results is directly related to cell and sample parameters.
- Verify that following conditions are respected:
 - CE surface \gg WE surface
 - Constant and stable sample active area
 - Same reference electrode for all measurements



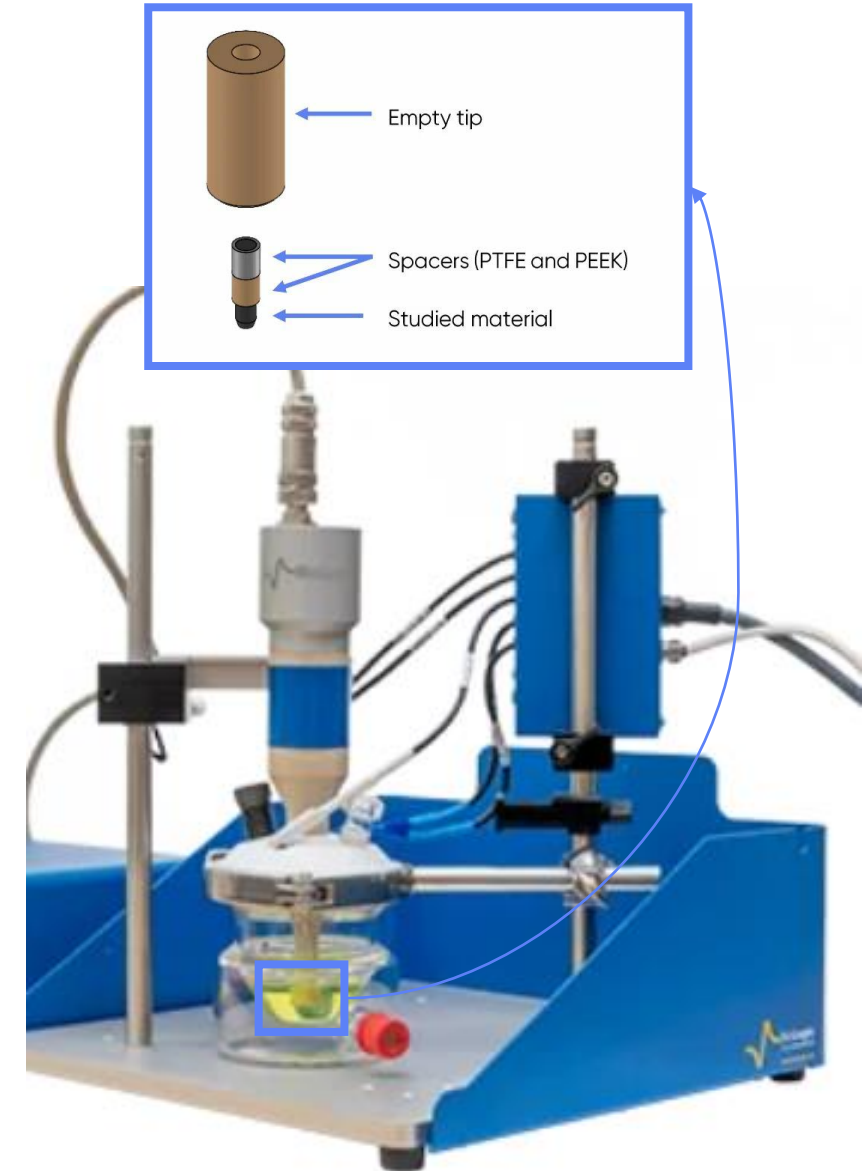
How do I select correct bandwidth?

- To verify quickly if the correct bandwidth is selected (no oscillation and stable measurement), you can follow these steps:
 - Change the Bandwidth factor. Start with a lower value. If decreasing the bandwidth factor does not work, try to increase it. The faster, the better.
 - For potentio-dynamic measurements carried out at high scan rates, fast bandwidths must be set.
 - The hardware ohmic drop compensation slows down the regulation loop, so in some cases, you may need to decrease the bandwidth.
 - For Premium range potentiostats, adjust bandwidths 7, 8, 9 first. Then, if the measurement still shows signs of oscillation try the advanced bandwidths 1 to 6.

Note: To go further, refer to Get more from your potentiostat, Understanding bandwidth & its effect on measurements (articles), Application Note #04; Technical Notes #35

Why should I use Rotating Disk Electrode (RDE) during Tafel Plot experiment?

- Tafel equation is valid if the concentrations at the electrode are approximately equal to the bulk concentrations
- It assumes that the electrode mass transfer rate is not limiting
- RDE ensures **the respect of condition to apply Tafel equation** (solution convection enables concentration renewal at the electrode)





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