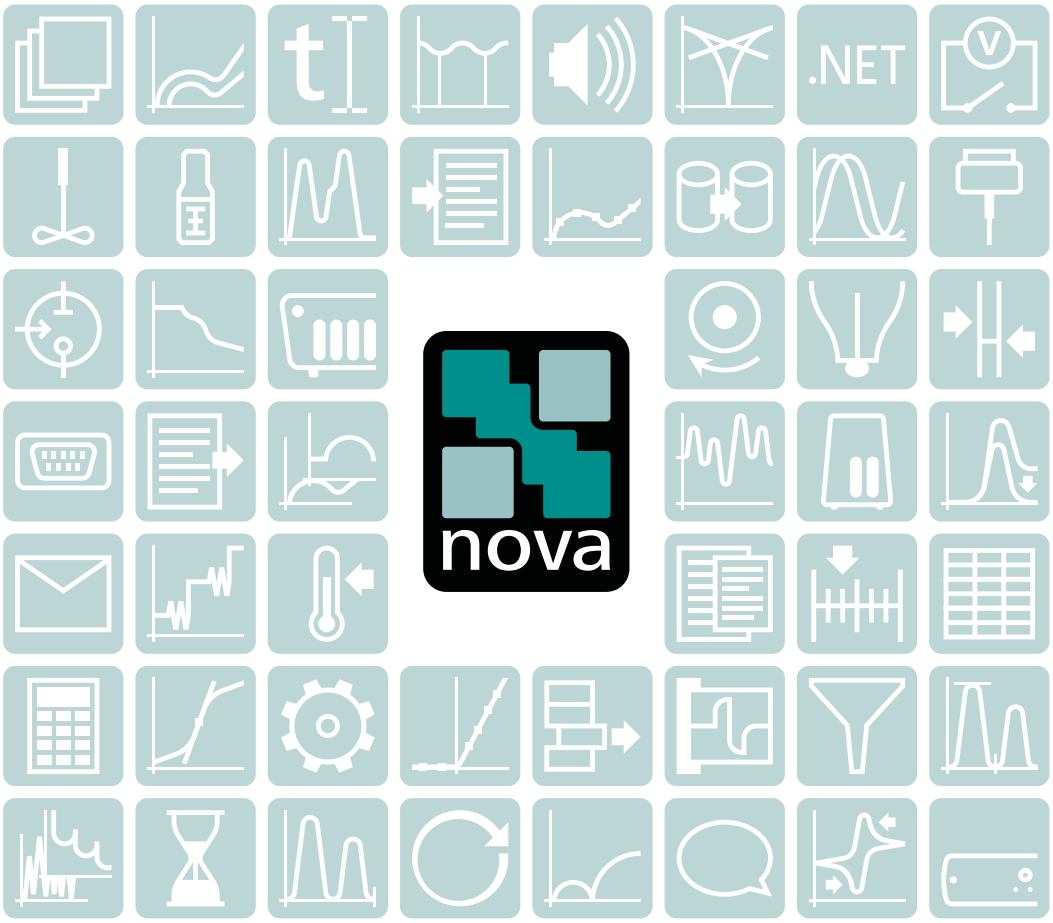
NOVA



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User Manual

2.1.4 / November, 2018

Metrohm Autolab

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NOVA

2.1.4

User Manual

2.1.4 /
November, 2018

MVB/JVD

Metrohm Autolab Teachware
Metrohm Autolab B.V.
3526 KM, Utrecht

Although all the information given in this documentation has been checked with great care, errors cannot be entirely excluded. Should you notice any mistakes please send us your comments using the address given above or at autolab@metrohm.com.

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1 NOVA installation

This chapter describes how to install the NOVA software on the host computer and to how connect Autolab and external devices to the host computer.

The NOVA installation package is supplied on CD-ROM or USB support provided with the Autolab instrument. It can also be downloaded from the Metrohm Autolab webpage.

NOTICE

Leave the Autolab disconnected from the computer when installing NOVA for the first time.

1.1 Software compatibility

NOVA requires Windows 7 or later as operating systems in order to run properly. NOVA can be installed on 32 bit and 64 bit versions of Windows.

NOTICE

Previous versions of Windows are not supported.

The minimum and recommended specifications are reported in *Table 1* and *Table 2*, respectively.

Table 1 Overview of the minimum specifications for NOVA

CPU	1 GHz or faster 32-bit (x86) or 64-bit (x64) processor
RAM	2 GB RAM
HD	20 GB available hard disc space
GPU	DirectX 9.0c compliant display adapter with 64 MB RAM

Table 2 Overview of the recommended specifications for NOVA

CPU	Intel Core i5 or equivalent AMD processor
RAM	8 GB RAM

HD	128 GB available hard disc space
GPU	DirectX 9.0c compliant display adapter with 1 GB RAM

NOTICE

The installation of the .NET 4.5 framework is required in order to install NOVA. If the .NET framework is already installed, the installation wizard will directly install NOVA on the computer. If the .NET framework is missing or of the correct version is not found on the computer, you will be prompted to install the .NET framework before the installation of NOVA can be completed.

1.2 Hardware compatibility

NOVA provides support for all Autolab instruments with a USB interface (internal or external), **except** the following legacy instruments:

- µAutolab (type 1)
- PSTAT10

Furthermore, NOVA provides support for all Autolab extension modules, **except** the following legacy modules:

- FRA modules (first generation)
- ADC124
- DAC124
- DAC168

1.3 Software installation

Double click the **nova-setup.exe** executable provided on the installation CD-ROM or USB support or downloaded from the Metrohm Autolab website to start the installation of the NOVA software.

An installation Wizard will be started *(see figure 1, page 3)*.

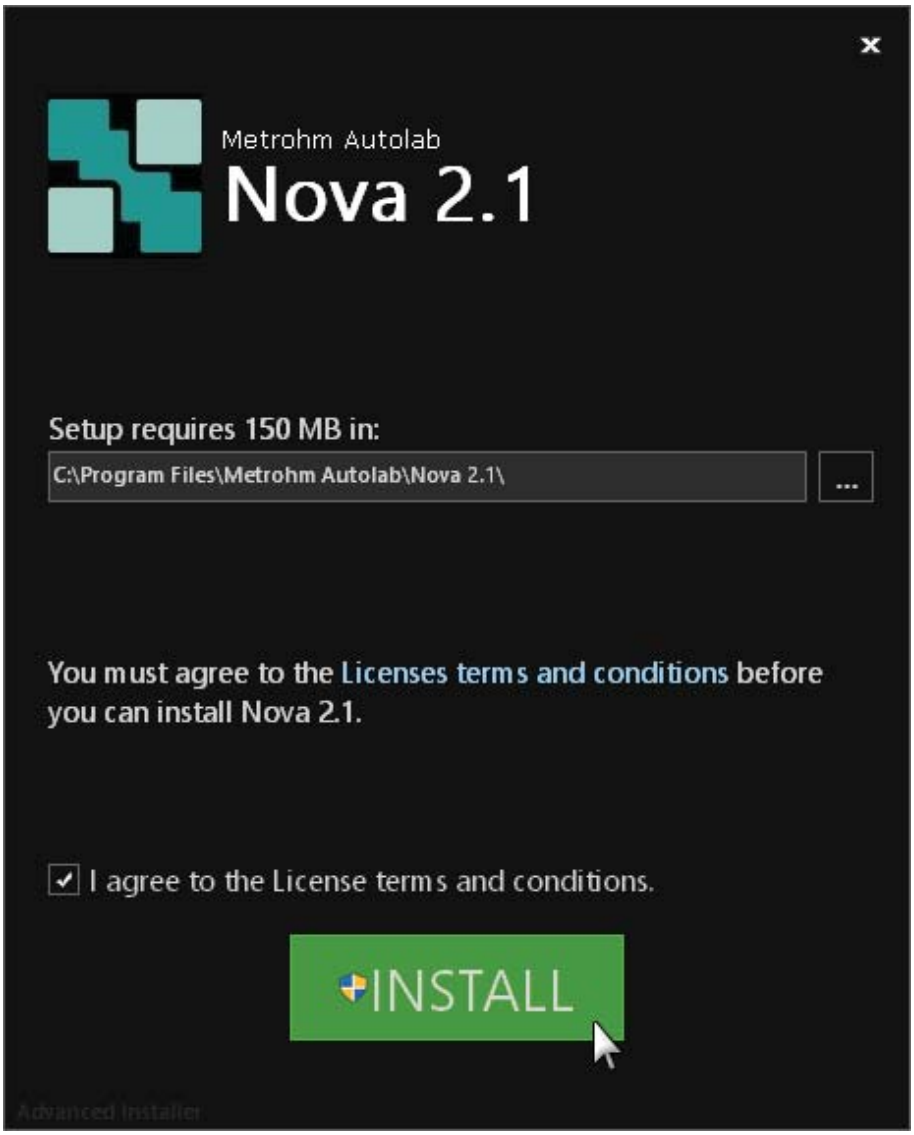


Figure 1 The installation wizard

Click the **INSTALL** button to start the installation. The files will be copied on the computer. If needed, the installation folder can be changed using the installation wizard.

When prompted to do so, please click the **Install** button provided in the Metrohm Autolab Driver installation window *(see figure 2, page 4)*.

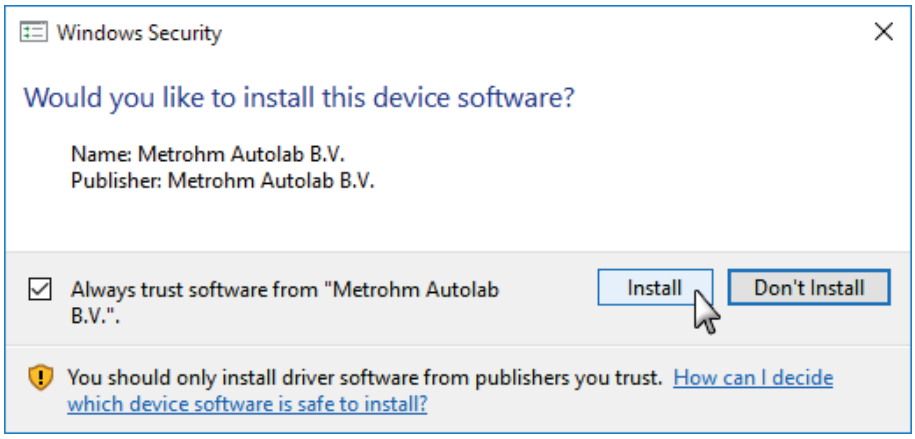


Figure 2 Install the Metrohm Autolab device drivers

NOTICE

Make sure that the Always trust software from Metrohm Autolab B.V. check box is ticked.

When prompted to do so, please click the **Install** button provided in the Avantes Driver installation window *(see figure 3, page 4)*.

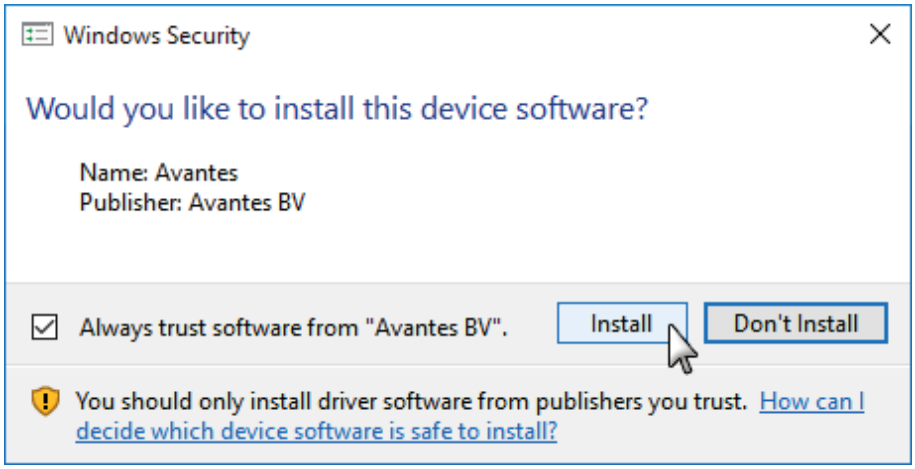


Figure 3 Install the Avantes device drivers

NOTICE

Make sure that the Always trust software from Avantes BV check box is ticked.

The installer will indicate when the installation is completed, as shown in *Figure 4*.

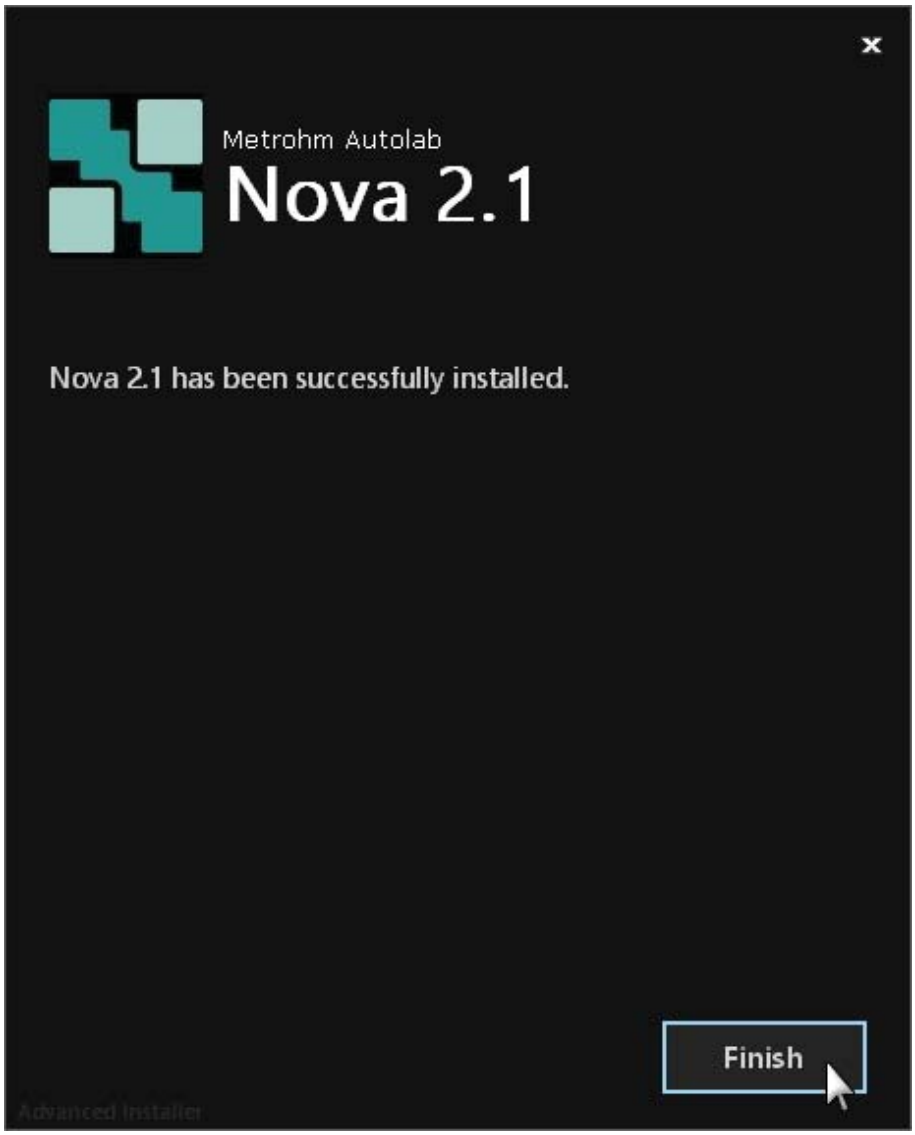


Figure 4 The installation is complete

1.4 External devices

The following additional external devices can be connected to the host computer:

- **Metrohm liquid handling devices:** these devices can be used to handling liquid samples and to automate the handling thereof.
- **Spectrophotometers:** the Autolab or the supported Avantes spectrophotometers can be used to perform spectroelectrochemical measurements in combination with the Autolab potentiostat/galvanostat.
- **Autolab RHD Microcell HC:** this device can be used to perform temperature-controlled measurements.

1.4.1 Metrohm Devices support

NOVA provides support for a selection of Metrohm liquid handling and automation devices.

The following devices are supported through a **USB** connection to the host computer:

- Metrohm 814 USB Sample Processor
- Metrohm 815 Robotic USB Sample Processor
- Metrohm 846 Dosing Interface
- Metrohm 858 Professional Sample Processor

The following devices are supported through a **MSB** connection to one of the **USB** controlled devices listed above:

- Metrohm 800 Dosino
- Metrohm 801 Magnetic Stirrer
- Metrohm 803 Titration Stand with Stirrer and Pump
- Metrohm 804 Titration Stand
- Metrohm 6.2148.010 MSB Remote Box

The following devices are supported through a **specific** connection to one of the **USB** controlled devices listed above:

- Metrohm 802 Rod Stirrer
- Metrohm 741 Magnetic Stirrer
- Metrohm 786 Swing Head
- Metrohm 843 Pump Station
- Metrohm 823 Membrane Pump
- Metrohm 772 Peristaltic Pump

NOTICE

At least one Metrohm device connected through **USB** is required in order to control the supported devices.

NOTICE

The supported Metrohm devices can be used with or without the Autolab connected to the computer.

1.4.2 Metrohm Devices installation

Connecting a **USB** controlled Metrohm device to the host computer will trigger the installation of the instrument *(see figure 5, page 7)*.

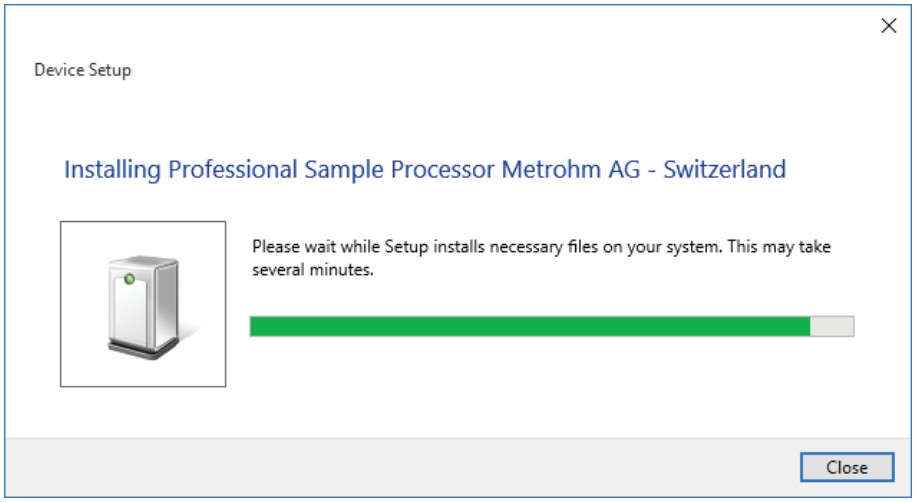


Figure 5 The Metrohm Device Driver installer

The installation will complete automatically.

NOTICE

In order to control the supported Metrohm Sample Processors, an additional Windows component must be present on the computer. The controls for the Metrohm Sample processors use the **Microsoft msxml6.0.dll** library for the configuration files (XML file format). This component may not be preinstalled on every Microsoft operating system. Please ensure the availability of this dll on the operating. If this package is missing, please download the installation package from the Microsoft website.

1.4.3 Spectrophotometer support

NOVA provides support for Autolab spectrophotometers.

The following Autolab spectrophotometer are supported through a **USB** connection to the host computer:

- Autolab Spectrophotometer UA
- Autolab Spectrophotometer UB

Additionally, compatible Avantes spectrophotometers are also supported when connected to the host computer through a **USB** connection. The following devices are supported:

- AvaSpec ULS2048-USB2

- AvaSpec ULS3648-USB 2

NOTICE

The supported spectrophotometers can be used with or without the Autolab connected to the computer.

1.4.4 Spectrophotometer installation

Connecting a USB controlled Metrohm Autolab Spectrophotometer (or a compatible Avantes Spectrophotometer) to the host computer will trigger the installation of the instrument *(see figure 6, page 8)*.

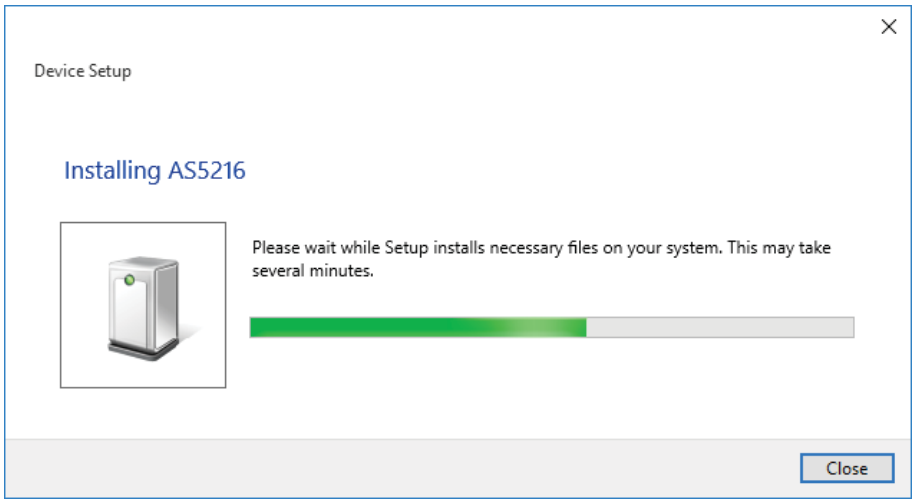


Figure 6 The Spectrophotometer installer

The installation will complete automatically.

1.4.5 Autolab RHD Microcell HC support

NOVA provides support for the complete Autolab RHD Microcell HC product range.

NOTICE

The supported Autolab RHD Microcell HC devices can be used with or without the Autolab connected to the computer.

1.4.6 Autolab RHD Microcell HC installation

No driver is required to control the Autolab RHD Microcell HC. When this type of device is connected to the host computer, it is immediately recognized by NOVA and listed in the **Instruments** panel.

NOTICE

The Autolab RHD Microcell HC is only detected by NOVA if a stage is connected to the controller with a cell mounted on the stage.

NOTICE

The Autolab RHD Microcell HC is connected to the host computer through a serial port. If no serial port is present on the computer, a USB to Serial port adapter can be installed. The drivers required for this adapter are not included in the installation package of NOVA and need to be installed separately.

1.5 Powering the instrument

In order to use the instrument, it must be connected to the mains using the mains connection socket, located on the back plane of the instrument. Before connecting the instrument to the mains make sure that the mains output voltage matches the value indicated on the main voltage indicator, located above the connector *(see figure 7, page 9)*.

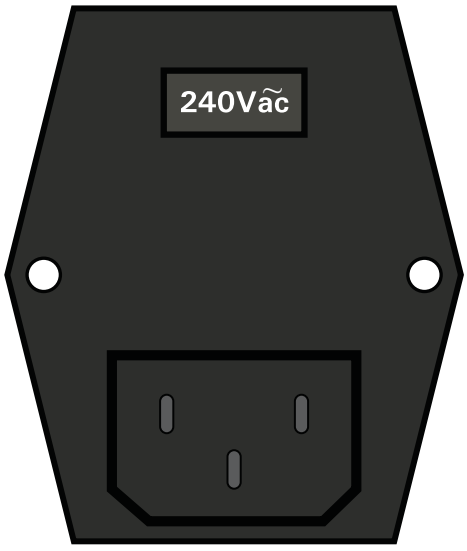


Figure 7 The required mains voltage is indicated above the connector

CAUTION

Connecting Autolab instrumentation to the wrong mains voltage may result in damage to the instrument.

1.6 Autolab hardware installation

After NOVA has been installed, connect the Autolab instrument to the computer using an available USB port. Switch on the instrument or plug the power supply in the external USB interface.

This will trigger the installation of the instrument *(see figure 8, page 10)*.

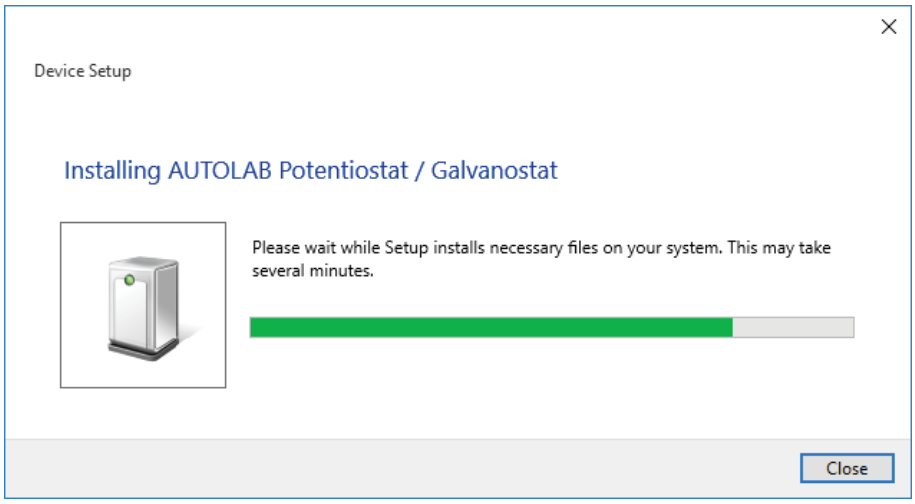


Figure 8 The Autolab installer

The installation will complete automatically.

NOTICE

The **Nova only** driver is used during this installation process.

If needed, it is possible to adjust the driver used to control the Autolab potentiostat/galvanostat. Start the Autolab Driver manager application by using the shortcut provided in the Start menu (All Programs – Autolab – Tools – Driver manager). This will start the Driver Manager application *(see figure 9, page 11)*.

Figure 9 The Driver Manager application

The Driver Manager can be used at any time to select the driver to use to control the Autolab. Two drivers are available:

- **Nova only (recommended setup):** this is the latest driver for the Autolab, allowing up to 127 instruments to be connected to the host computer. This driver is compatible with 32 bit and 64 bit versions of Windows.
- **Legacy driver:** this is an older driver version which can be used in combination with the GPES or FRA software. No further developments are planned for this driver. The maximum number of devices connected to the host computer is 8. Data transfer may be slower than with the NOVA only driver. This driver is **only** compatible with 32 bit versions of Windows.

NOTICE

The **Nova only** driver will not work with previous versions of NOVA (version 1.10 and older). In order to use previous versions of NOVA, it is necessary to start the Driver Manager application provided with the previous version and select one of the available drivers provided with this previous version (please refer to the **Getting Started** manual of the previous version of NOVA for more information).

Click the installation button for the required driver to change the device driver and follow the instructions on screen. The selected driver will be installed for all connected Autolab instruments. New instruments connected to the host computer will be configured using the selected driver.

NOTICE

The **Driver Manager** application can be used to change the device driver at any time.

1.7 Software license

The Autolab NOVA software, and all its components, provided in conjunction with the Metrohm Autolab potentiostat/galvanostat instruments is copyrighted and owned by Metrohm Autolab.

The software is provided as a **Free Licensed Closed-Source** product with limited warranty. The software can be installed on any computer without specific authorization from Metrohm Autolab.

Metrohm Autolab retains the copyright to the software. You may neither modify nor remove references to confidentiality, proprietary notices or copyright notices. Modifications of the software in part or as a whole is not permitted.

Metrohm Autolab warrants that the software, when operated properly, is suitable for the specified use with the electrochemical instrumentation from Metrohm Autolab or compatible external instrumentation.

Metrohm Autolab is exempt from further warranty or liability. Metrohm Autolab is neither liable for third-party damages or consequential damage not for loss of data, loss of profits or operating interruptions, etc.

1.8 Intended use

All Metrohm Autolab products are designed for electrochemical research and development within the normal environment of a laboratory. The instrumentation shall therefore only be used for this purpose and within the specified environmental conditions. All other uses fall out of the scope of the instrumentation and may lead to voiding of any warranty.

1.9 Options

The application options can be defined by selecting the *Options* from the **Edit** menu. A window will be displayed, showing two different sections *(see figure 10, page 13)*.

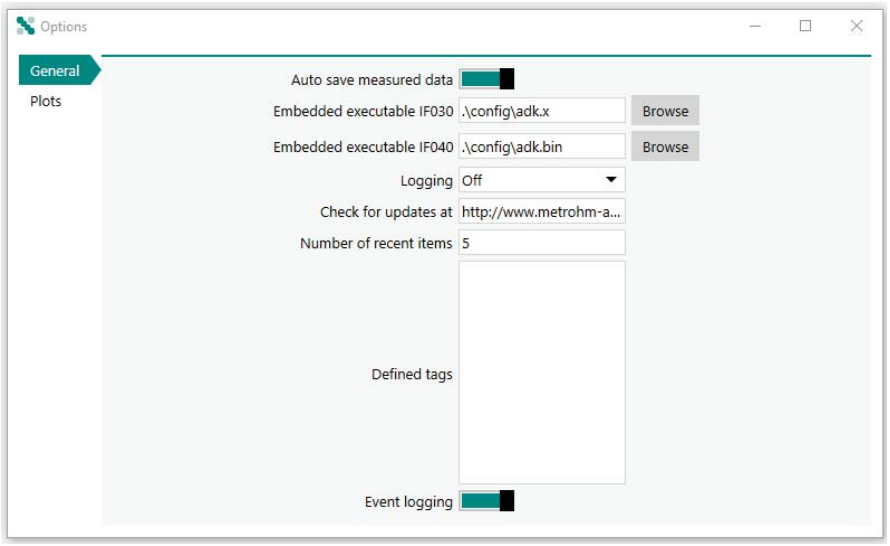


Figure 10 The application Options window

The following properties are available in the **General** section *(see figure 10, page 13)*:

- **Auto save measured data:** specifies if measured data should be saved automatically at the end of each measurement, using the provided toggle. This option is on by default.
- **Embedded executable IF030:** specifies the path to the embedded application for instrument fitted with the **IF030** controller, using the provided Browse button. This is a system property, do **not** change this unless instructed by Metrohm Autolab.
- **Embedded executable IF040:** specifies the path to the embedded application for instrument fitted with the **IF040** controller, using the provided Browse button. This is a system property, do **not** change this unless instructed by Metrohm Autolab.

- **Logging:** specifies if error logging should be used and which level of logging should be used, if applicable, using the provided drop-down list. This is a system property, do **not** change this unless instructed by Metrohm Autolab.
- **Check for updates at:** specifies the URL for version checks of NOVA. This is a system property, do **not** change this unless instructed by Metrohm Autolab.
- **Number of recent items:** defines the number of recent items shown in the **Recent items** panel of the dashboard. The default value is 5. Please refer to *Chapter 4.2*, for more information on the recent items.
- **Defined tags:** provides a list of tags used in NOVA. This list is empty by default and is automatically populated by user-defined tags through the tagging feature of NOVA. If needed, tags can be removed or added to this list directly. More information on the use of tags can be found in *Chapter 6.8*.
- **Event logging:** specifies if event logging should occur during the measurement, using the provided toggle. This option is on by default. For more information about **Event logging** please refer to *Chapter11.9.2*

CAUTION

Modifying the system properties shown in the **General** section can interfere with the operation of the instrument. Do **not** change these properties unless instructed by Metrohm Autolab.

The **Plots** section displays the default plot options used in NOVA for all plots *(see figure 11, page 15)*.

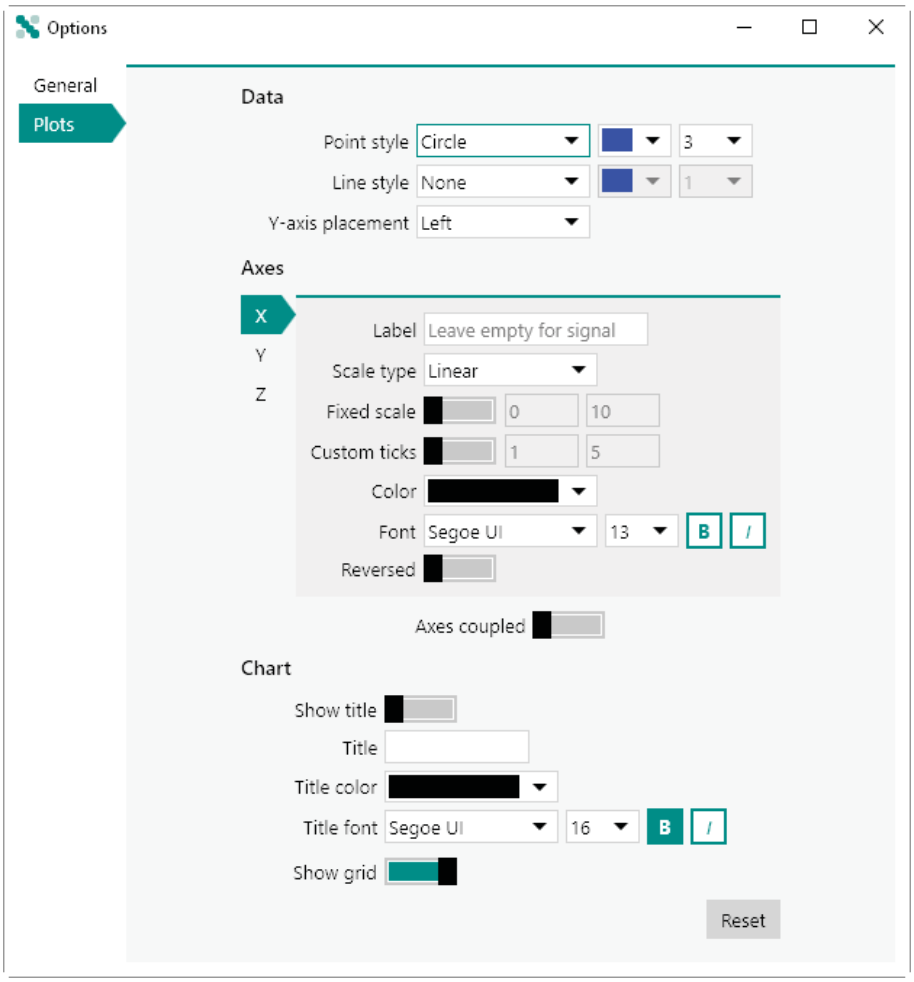


Figure 11 The plot options

In this section all the default options for plots can be specified. Clicking the Reset button will reset all the options to the factory default values.

NOTICE

Please refer to *Chapter 9.5.3* for more information on the Plot options.

2 Conventions

Throughout NOVA and all Metrohm Autolab products, the conventions detailed in this chapter are used.

2.1 Scientific conventions

The following scientific conventions are used:

- All units are specified in the International System of Units (SI), unless otherwise specified. See *B. N. Taylor, A. Thomson, The International System of Units (SI), NIST Special Publication 330, 2008 Edition* for more information.
- Electrochemical values like potential and current are indicated according to the International Union of Pure and Applied Chemistry (IUPAC) convention. Positive currents and (over)potentials are associated with oxidation processes. Negative currents and (over)potentials are associated with reduction processes. See *A. D. McNaught, A. Wilkinson, IUPAC, Compendium of Chemical Terminology: IUPAC Recommendations, Blackwell Science: Oxford, England; Malden, MA, USA, 1997* for more information.

2.2 Software conventions

The following standard interaction conventions are used in NOVA:

- A right-handed mouse where the left button is used for selecting items and the right button may open context-related menus is assumed.
- Quickly pressing and releasing the mouse button is called ‘Clicking’. A click of the left mouse button on a menu option, a button, an input item on the screen, will result in an action.
- Quickly pressing and releasing the right mouse button is called ‘Right-clicking’. A click of the right mouse button on a suitable location on the screen opens a context-sensitive menu, if applicable.
- By clicking and holding down the left mouse button you can ‘Drag’ items from one window and ‘Drop’ it in another by releasing the button. This action will be called ‘Drag and Drop’ and it is the key mechanism for creating a procedure.
- Quickly pressing and releasing the mouse button twice is called 'Double-clicking'. A double-click of the left mouse button is used to perform particular actions, and mainly is applied through standard usage in window actions.

The following selection methods are used in NOVA:

- To select any item on screen, click the item.
- To select consecutive items on screen, click the first item, press and hold down **[SHIFT]**, and then click the last item.
- To select nonconsecutive items on screen, press and hold down **[CTRL]**, and then click each item.

2.3 Numbering conventions

All **numeric** values are defined in NOVA according to the local culture defined for the Windows operating system. Depending on these settings, the decimal separator symbol can either be **.** or **,**.

Improper use of the local culture settings defined in Windows may lead to wrong values. For example, typing 0,3 in NOVA on a computer which uses the . as decimal separator will be validated as 3.

NOTICE

It is recommended to consult the local culture settings defined in Windows before using the NOVA software.

Scientific (exponential) numbering is done using the **e** or **E** symbol. A value of **1e2** or **1E2** is converted to **100**.

The following prefixes are using in NOVA for engineering notation:

- **T**, for *Tera* (1000000000000).
- **G**, for *Giga* (1000000000).
- **M**, for *Mega* (1000000).
- **k**, for *Kilo* (1000).
- **m**, for *Milli* (0.001).
- **µ**, for *Micro* (0.000001).
- **n**, for *Nano* (0.000000001).
- **p**, for *Pico* (0.000000000001).

2.4 Warning label conventions

The following warning labels are using throughout the documentation provided with all the Metrohm Autolab products *(see table 3, page 18)*:

Table 3 Warning conventions used in NOVA

	Warning This symbol draws attention to a possible life hazard or risk of injury.
	Warning This symbol draws attention to a possible hazard due to electrical current.
	Warning This symbol draws attention to a possible hazard due to heat or hot instrument parts.
	Warning This symbol draws attention to a possible biological hazard.
	Caution This symbol draws attention to a possible damage of instruments or instrument parts.
	Note This symbol marks additional information and tips.

2.5 NOVA information, warnings and errors

NOVA validates commands and command properties in real-time while the software is used or after each measurement. Depending on the situation, NOVA may provide validation information in the following way:

- **Information:** any item highlighted in blue indicates that information is available for the user to consider for improving the quality of the data. This indication is only provided at the end of a measurement, if applicable *(see figure 12, page 19)*.

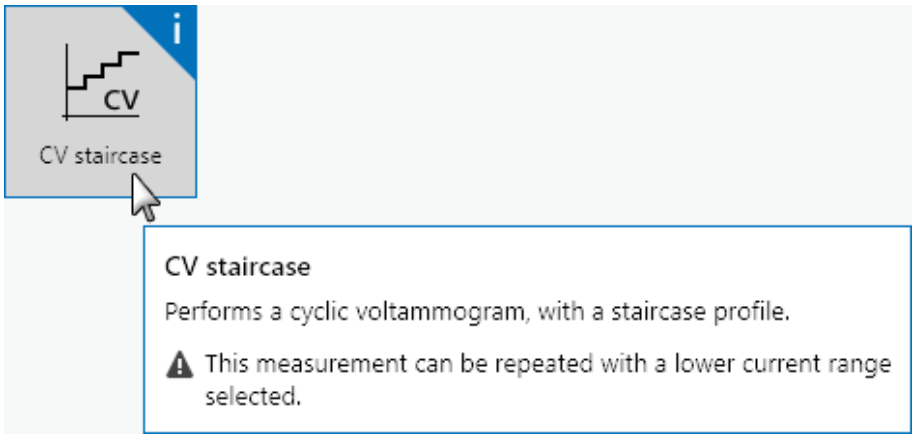


Figure 12 Information is highlighted in blue

- **Warning:** any item highlighted in yellow indicates that an issue has been identified and that user intervention is recommended in order to resolve the issue *(see figure 13, page 19)*. Whenever possible, the cause and a possible solution will be offered. It is possible to ignore the warning and continue working with the software however this may lead to invalid data.

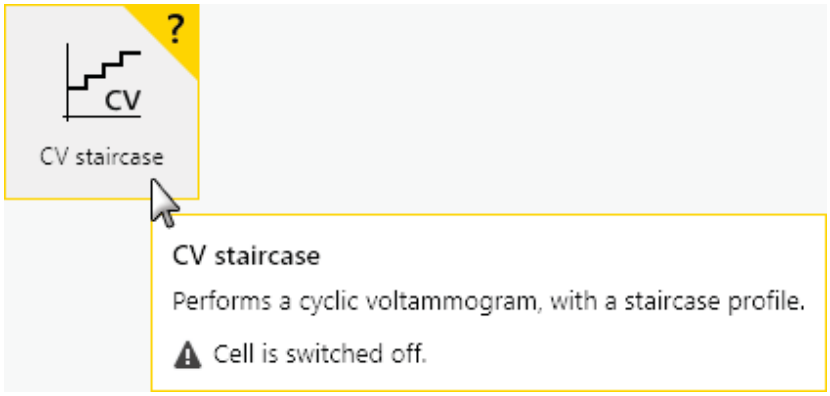


Figure 13 Warnings are highlighted in yellow

- **Error:** any item highlighted in red indicates that a problem has been identified and that user intervention is required in order to resolve the error *(see figure 14, page 20)*. Whenever possible, the cause and a possible solution will be offered. It is **not** possible to ignore the error. No measurements are possible until the error is resolved.

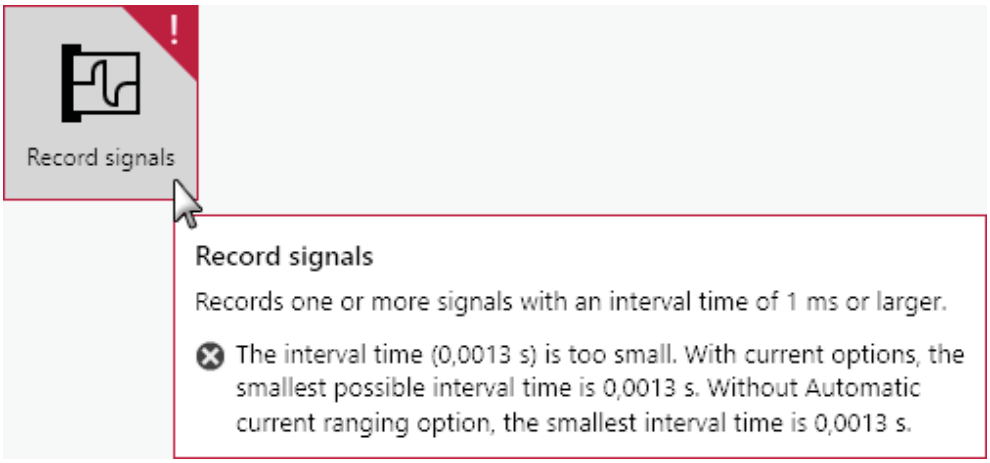


Figure 14 Errors are highlighted in red

2.6 NOVA menus and controls

This chapter describes the software menus and controls provided in NOVA.

File	
Close	Closes the active tab. Keyboard shortcut: **[CTRL]** + **[F4]**
Close All	Closes all open tabs. Keyboard shortcut: **[CTRL]** + **[SHIFT]** + **[F4]**
Save	Saves the content of the active tab as procedure, data or schedule. Keyboard shortcut: **[CTRL]** + **[S]**
Save As...	Saves the content of the active tab as procedure, data or schedule with the specified file and location.
Save All	Saves the content of all open tabs as procedure, data or schedule. Keyboard shortcut: **[CTRL]** + **[SHIFT]** + **[S]**
Exit	Closes the NOVA application. Keyboard shortcut: **[ALT]** + **[F4]**

Edit	
Undo 'Action name'	Undoes the specified action. Keyboard shortcut: **[CTRL]** + **[Z]**

Redo 'Action name'	Redoes the specified action. Keyboard shortcut: **[CTRL]** + **[Y]**
Cut	Cuts the selected item(s) to the clipboard. Keyboard shortcut: **[CTRL]** + **[X]**
Copy	Copies the selected item(s) to the clipboard. Keyboard shortcut: **[CTRL]** + **[C]**
Paste	Pastes the items in the clipboard at the specified location. Keyboard shortcut: **[CTRL]** + **[V]**
Select All	Selects all visible items. Keyboard shortcut: **[CTRL]** + **[A]**
Options	Specifies the default options used in the application.

View	
Zoom in	Zooms in on a plot. Keyboard shortcut: **[CTRL]** + **[=]**
Zoom out	Zooms out on a plot. Keyboard shortcut: **[CTRL]** + **[-]**
Fit all	Adjusts the plot area to the best possible scale. Keyboard shortcut: **[F4]**
Manual control	Displays the Manual control panel for the default instrument. Keyboard shortcut: **[F10]**

Measurement	
Run	Starts the procedure defined in the selected tab on the **default** instrument. Keyboard shortcut: **[F5]**
Run on ▸	Starts the procedure defined in the selected tab on the **specified** instrument.
Instrument #1	
Instrument #2	
...	

Pause	Pauses the running command in the selected tab.
Skip	Skips the running command in the selected tab.
Stop	Stops the measurement running in the selected tab.

Help	
User manual	Displays the NOVA User Manual. Shortcut key: **[F1]**
About	Displays the About dialog.

3 Release notes

This chapter describes the release notes of the current and previous versions of NOVA. The release notes are provided in reverse chronology. The following version have been released:

- **Version 2.1.4:** minor update of NOVA 2.1.
- **Version 2.1.3:** minor update of NOVA 2.1. *Version 2.1.3 release (see chapter 3.2, page 28)*. This version was released on March 9th, 2018.
- **Version 2.1.2:** minor update of NOVA 2.1. *Version 2.1.2 release (see chapter 3.3, page 34)*. This version was released on May 5th, 2017.
- **Version 2.1.1:** minor update of NOVA 2.1 *Version 2.1.1 release (see chapter 3.4, page 34)*. This version was released on March 24th, 2017.
- **Version 2.1:** the current major release of NOVA *Version 2.1 release (see chapter 3.5, page 44)*. This version was released on November 15th, 2016.
- **Version 2.0.2:** minor update of NOVA 2.0 *Version 2.0.2 release (see chapter 3.6, page 58)*. This version was released on July, 6th, 2016.
- **Version 2.0.1:** minor update of NOVA 2.0 *Version 2.0.1 release (see chapter 3.7, page 66)*. This version was released on April, 1st, 2016.
- **Version 2.0:** the original major release of NOVA 2 *Version 2.0 release (see chapter 3.8, page 80)*. This version was release on October, 7th, 2015.

3.1 Version 2.1.4 release

Version 2.1.4 adds the following new functionality:

1. A new **Default Procedure** "Chrono charge discharge galvanostatic" was added, along with a new **Demo Database** file that demonstrates this procedure. *Chrono charge discharge galvanostatic (see chapter 3.1.1, page 24)*.
2. Possibility to edit plot properties within the **Overlay** tab. *Editable overlay plot properties (see chapter 3.1.2, page 25)*.
3. Option to disable event logging. *Disable event logging (see chapter 3.1.3, page 26)*
4. Possibility to import a table in the Repeat for multiple values command while the procedure is running. *Import table in the repeat loop during a running procedure (see chapter 3.1.4, page 27)*

3.1.1 Chrono charge discharge galvanostatic

A new **Default procedure** has been added: **Chrono charge discharge galvanostatic**. This procedure allows battery researchers to get started quickly and easily with galvanostatic charge and discharge measurements. The charge discharge sequence is configured inside a repeat loop. I is applied and E is measured. The battery (or other device) charges at a constant current until a cutoff is reached on the WE(1).Potential signal. Following the cutoff, the procedure continues to the discharge step. All relevant parameters may be configured by the user, including:

- charge and discharge current
- duration of the charge and discharge steps
- values of the potential cutoff (charge and discharge)
- number of charge discharge cycles

As expected, the full flexibility of NOVA 2 is available allowing additional signals to be added, changes to the data sampling interval, addition and configuration of plots. The default procedure may be modified with any command tile to add pre or post conditioning of the battery or device, or to add additional measurements (such as EIS) to the repeated sequence. For more information, please proceede to: *Chrono charge discharge galvanostatic (see chapter 8.4.10, page 583)*.

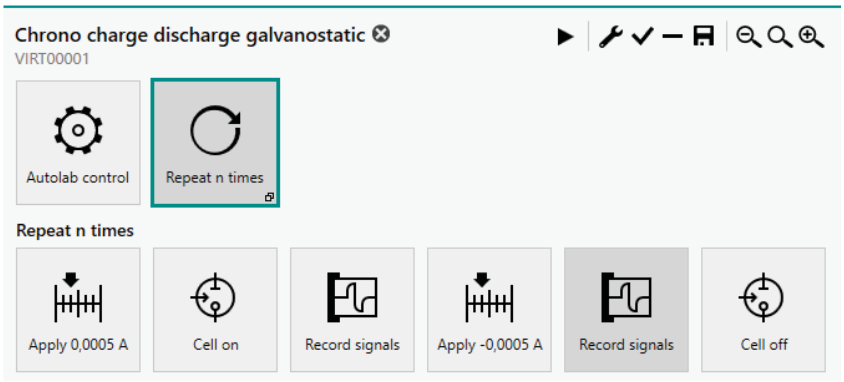


Figure 15 Chrono charge discharge galvanostatic default procedure sequence

A new **Demo database** file, Demo 22, has also been added. Demo 22 provides an example of the new **Chrono charge discharge galvanostatic** default procedure.

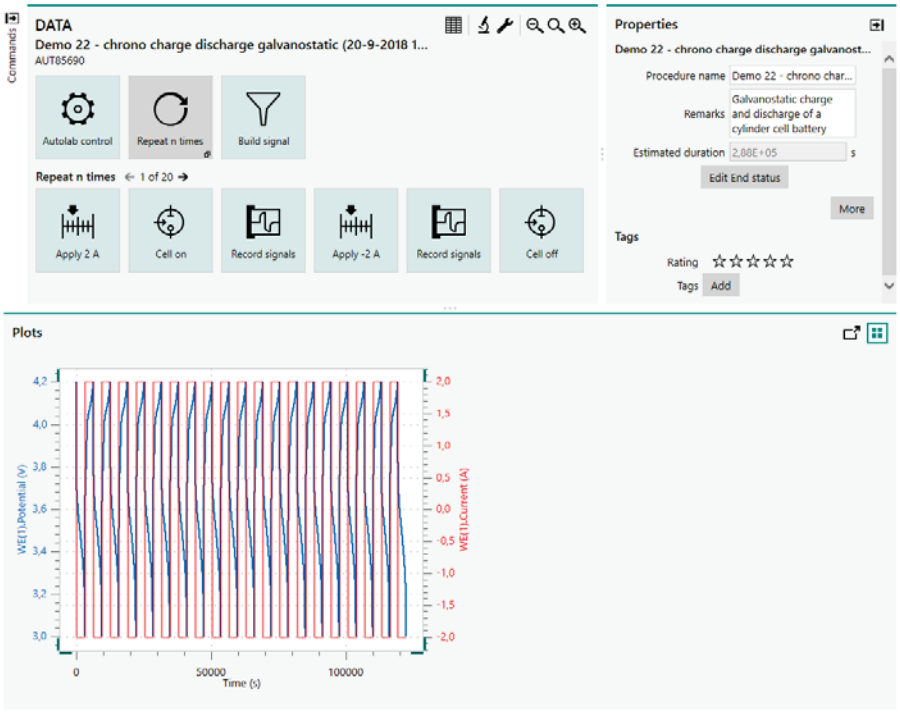


Figure 16 Demo data file 22 shows galvanostatic charge discharge of a cylinder cell battery

3.1.2 Editable overlay plot properties

The possibility to edit plot properties has been added to the **Overlay** tab. This new functionality allows the plotted data series to be configured, including the point or line styles and colors. Each data series in the overlay plot can now be given a title that is propagated automatically to the legend. The overlay plot can be given a title as well. For more detailed information, please procede to *Changing overlay plot properties (see chapter 14.3, page 838)*.

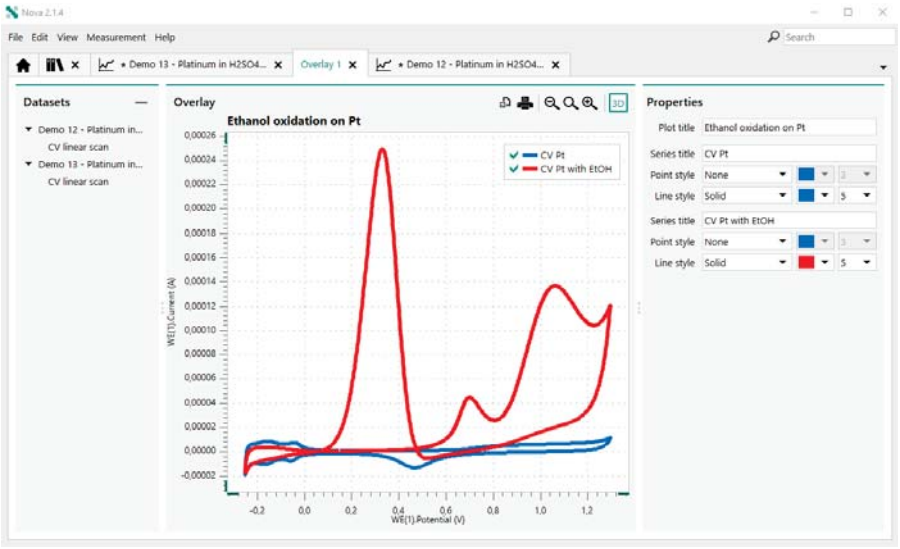


Figure 17 Overlay tab with a new plot properties panel

3.1.3 Disable event logging

The possibility to disable event logging has been added tp the **Application options**. When event logging is disabled, events such as cutoffs, user intervention, and the current range in which data points were collected will not be logged. Disabling event logging reduces slightly the size of the measurement data .nox file and reduces the RAM used when creating the .nox data file. Event logging is enabled by default. It is not recomended to disable event logging unless the measurement is expected to create a very large data file and RAM availability during data file creation is expected to be a problem. For more detailed information, please proceede to *Options (see chapter 1.9, page 13)*.

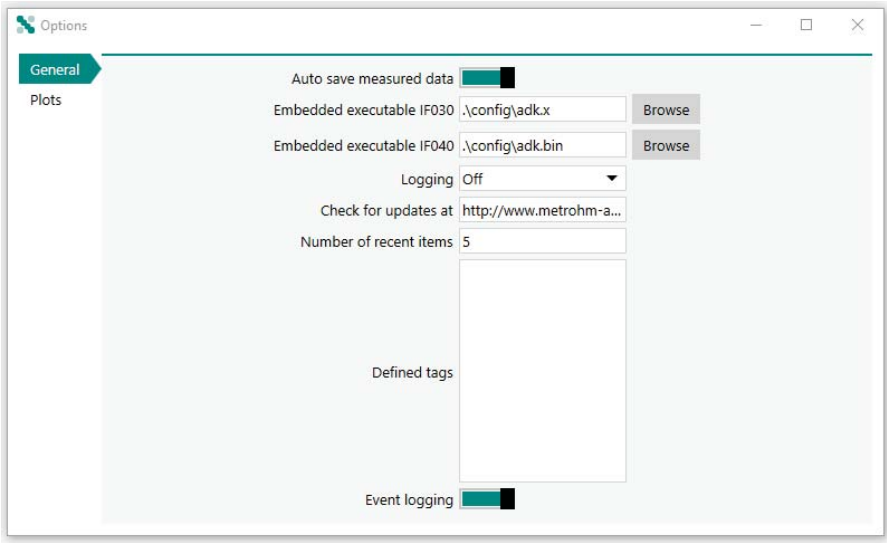


Figure 18 The application options window

NOTICE

Modifying the options shown in the **General** section of the application options can interfere with the operation of the instrument. Do **not** change these properties unless instructed by Metrohm Autolab.

3.1.4 Import table in the repeat loop during a running procedure

The possibility to import a table while the procedure is running has been added to the **Repeat** command. This new functionality allows the repeat values to be imported at the moment the Repeat command is encountered in the procedure sequence. Therefore, changes can be made to the values in the table during the measurement sequence, until the moment the command is executed. Use of this feature is recommended for advanced NOVA users only because validation cannot be perfomed on the values within the table when it is imported during run time. For more detailed information, please proceed to: *Import a table using the Import table option (see chapter 7.1.3.2.4, page 214)*.

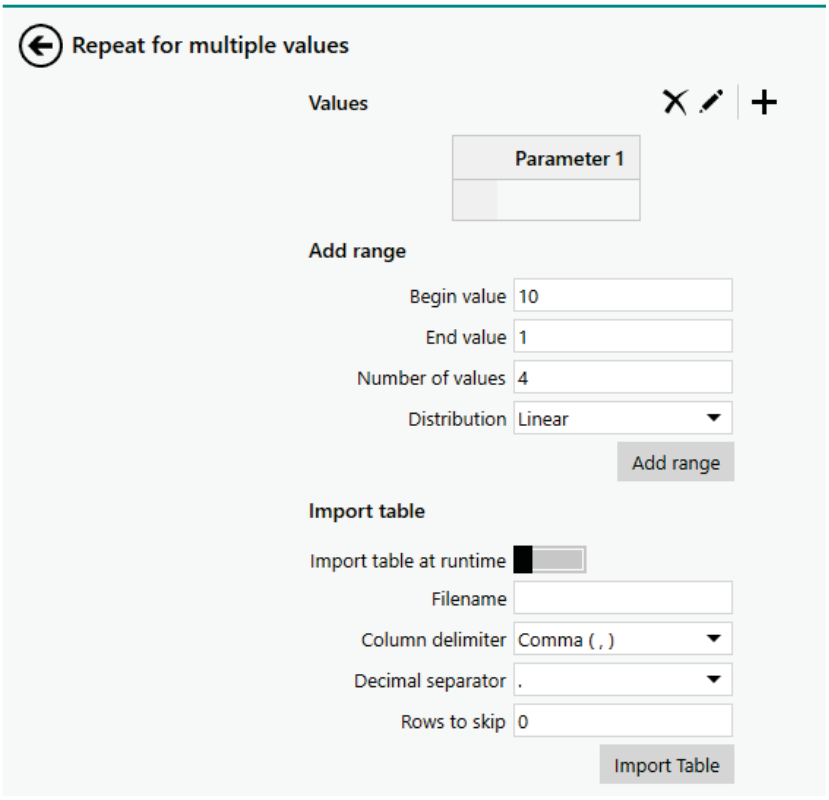


Figure 19 The repeat for multiple values command properties with a toggle to repeat a table at runtime

NOTICE

Please read all of the instructions and notes carefully before using this functionality. Detailed information is located here: *Import a table using the Import table option (see chapter 7.1.3.2.4, page 214)*.

3.2 Version 2.1.3 release

Version 2.1.3 adds the following functionality:

1. New procedure information command tile *Procedure information (see chapter 3.2.1, page 28)*.
2. Export to RelaxIS possibility *Export to RelaxIS (see chapter 3.2.2, page 29)*
3. Reconfiguration of the OCP command tile with improved functionality*OCP command (see chapter 3.2.3, page 30)*.
4. Possibility to import a table in the Repeat for multiple values command *Import table in Repeat command (see chapter 3.2.4, page 31)*.
5. Control of the light source shutter in the Spectrophotometer manual control screen *Light source shutter control (see chapter 3.2.5, page 31)*.
6. A **Demo Database** file for spectroelectrochemical LSV has been added *Demo database file (see chapter 3.2.6, page 32)*.
7. Data files are now visually distinguishable from procedure files in the **Procedure editor** due to green shading of the command tiles *Colored data file command tiles (see chapter 3.2.7, page 33)*.

3.2.1 Procedure information

A new command tile has been added to NOVA in order to facilitate the linking of procedure and measurement information, including **Remarks** and **Instrument serial number**, to exported data files, as shown in *(see figure 20, page 28)*.

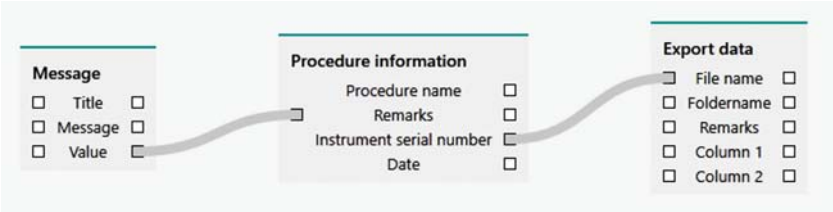


Figure 20 Linking of the Procedure information command

NOTICE

Use of the **Procedure information** command tile is optional.

NOTICE

More information on the **Procedure information** command is available in *Chapter 7.1.8*.

3.2.2 Export to RelaxIS

NOVA 2.1.3 offers the possibility to export electrochemical impedance spectroscopy data in the RelaxIS file format. This functionality has been added to the existing **Export data** command *Chapter 7.7.6*.

NOTICE

RelaxIS is a comprehensive software solution for the analysis of impedance spectra. This software is a product of **rhd instruments**. For more information, please visit *https://www.rhd-instruments.de/index.php/en/relaxis-en.html*.

The RelaxIS file format option is located in the File format drop down menu of the **Export data** command, as shown in *(see figure 21, page 29)*.

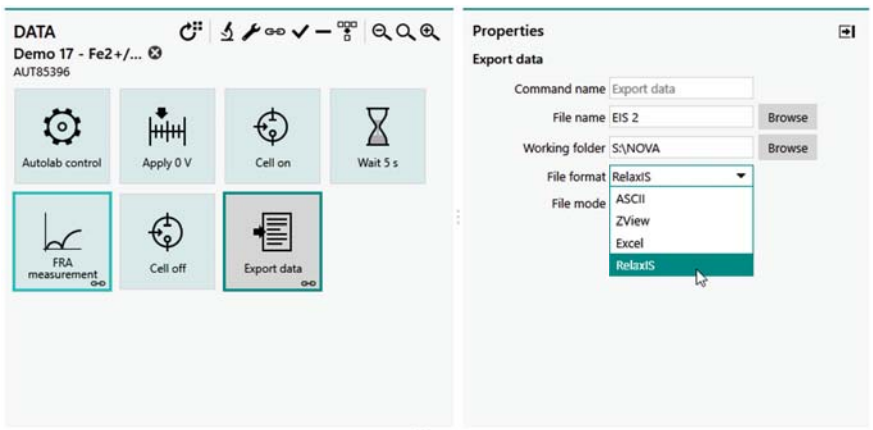


Figure 21 The export data command with RelaxIS file format

When the RelaxIS file format is selected, the list of link-able properties is pre-configued to those supported by the RelaxIS file type, as shown in *(see figure 22, page 30)*. Data from a **FRA measurement** can be linked

to the anchoring points of the **Export data** command. Additional fields for sample properties, such as thickness and area, as well as free variables, are available. This information can be inputted in message command tiles or in the Remarks property of the new **Procedure information** command tile.

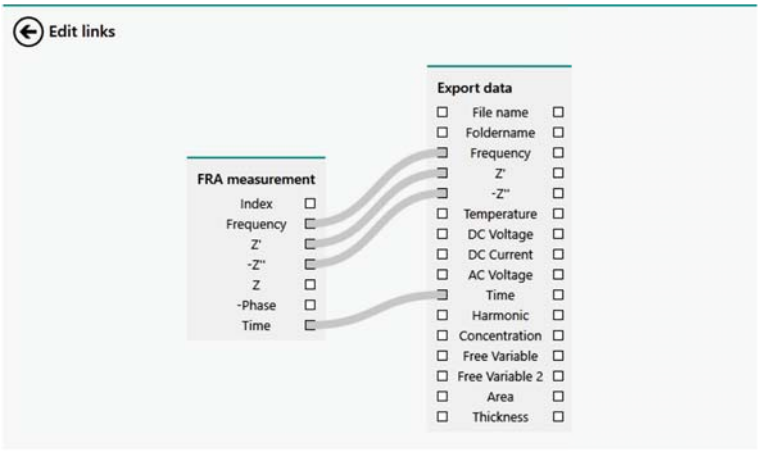


Figure 22 Linking of the FRA measurement data to the RelaxIS Export data command

NOTICE

For more information, please refer to the chapter describing the **Export data** command *Export data (see chapter 7.7.6, page 362)*.

3.2.3 OCP command

The **OCP** command has been reconfigured for improved functionality. The new OCP command is based on the **Record signals** command. This implementation allows all data associated with the OCP measurement to be stored, including the Time, Corrected time, and Cutoffs. There is no longer a seperate window that appears during the OCP determination. Instead, the following default plots appear in the **Plots frame**:

- WEPotential vs. Time
- dWEPotential/dt vs. Time

NOTICE

More information on the new implementation of the **OCP** command can be found in *Chapter 7.2.5*.

3.2.4 Import table in Repeat command

The **Repeat** for multiple values command now provides the possibility to import a table. The table can be imported from a CSV file, as shown in *(see figure 23, page 31)*.

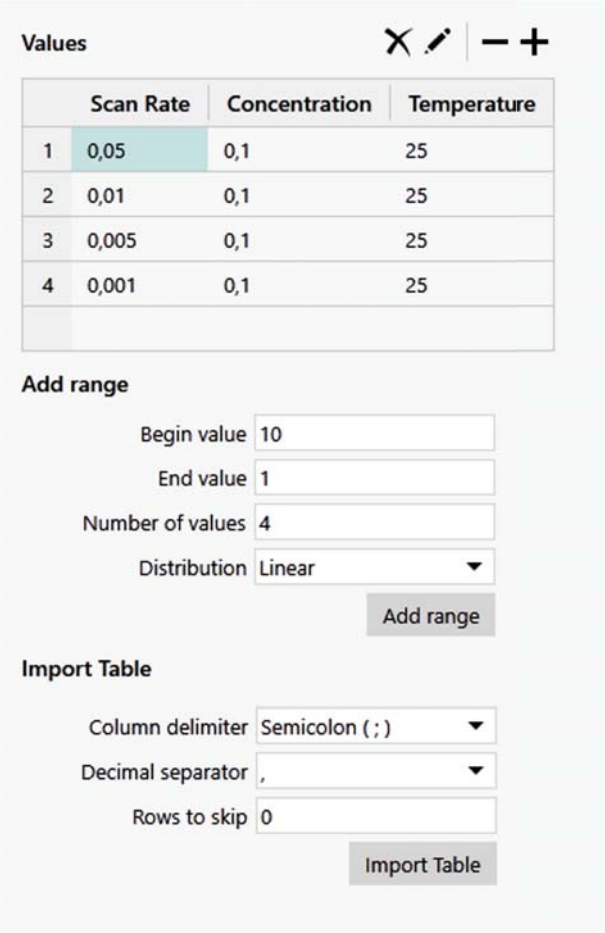


Figure 23 Import a table in the Repeat for multiple values command

NOTICE

More information on how to import a table in the Repeat command can be found in .

3.2.5 Light source shutter control

NOVA 2.1.3 adds the possibility to open and close the shutter of an Autolab light source from the Spectrophotometer control panel. A a toggle is provided that allows the light source shutter to be opened and closed using a TTL pulse from the default connected Autolab instrument.

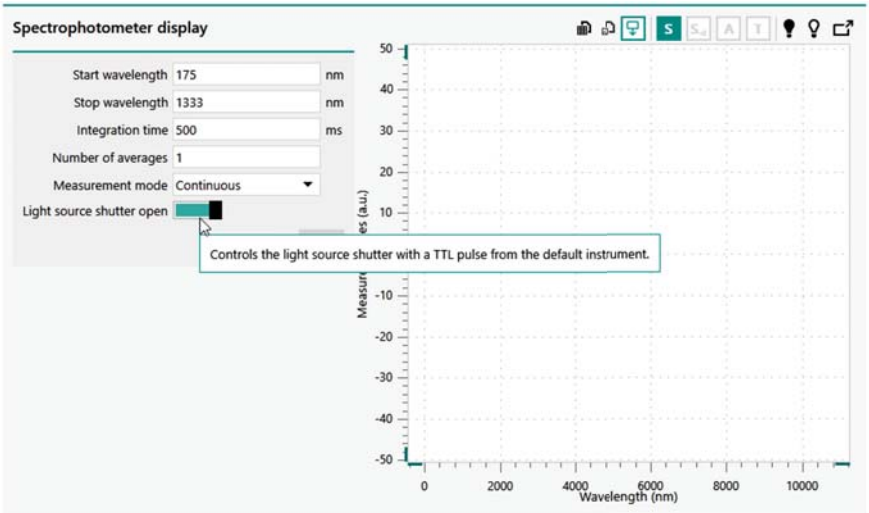


Figure 24 The light source shutter open toggle is located in the Spectrophotometer control panel

NOTICE

More information on the Spectrophotometer manual control panel of NOVA 2.1.3 can be found in *Chapter 5.4.2*.

3.2.6 Demo database file

A new file has been added to the **Demo database**. Demo data file 21 demonstrates linear sweep voltammetry with in-situ UV/Vis spectroscopy, as shown in *Demo database file (see chapter 3.2.6, page 32)*.

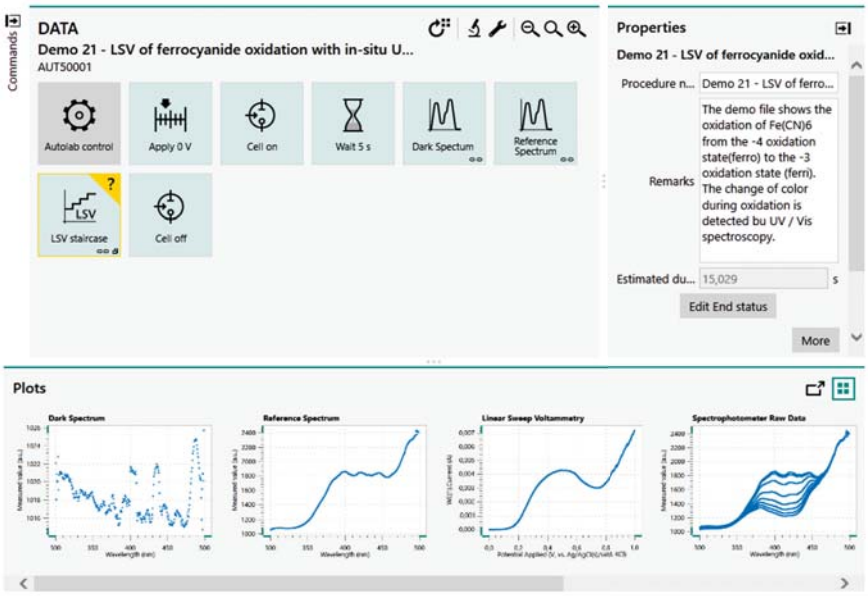


Figure 25 Demo data file 21 shows LSV of ferrocyanide oxidation with in-situ UV/Vis spectroscopy

3.2.7 Colored data file command tiles

The appearance of the command tiles within a data file has been altered to provide a visual contrast to the command tiles within a procedure file. This style change aims to provide a visual cue that a data file is open in the **Procedure editor**. The tiles in the data file are shaded green. In addition, the word **DATA** now appears at the top left corner of the **Procedure editor**, as shown in *(see figure 26, page 33)*.

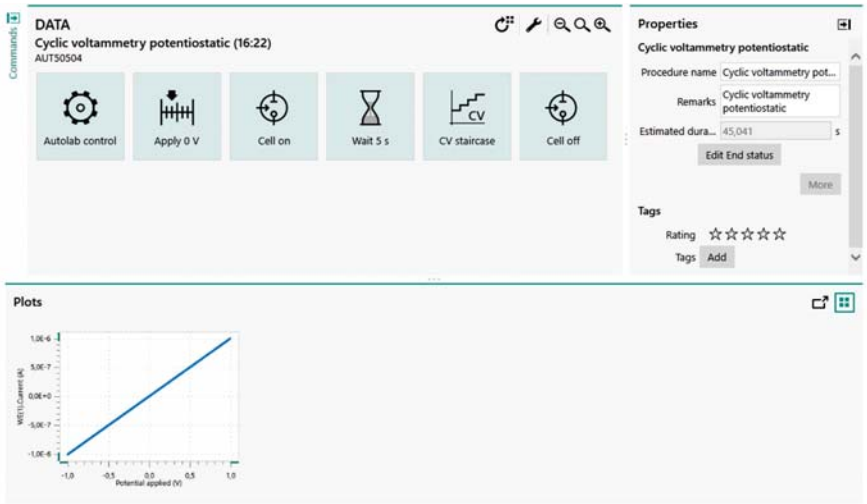


Figure 26 Command tiles within a data file are shaded green

3.3 Version 2.1.2 release

Version 2.1.2 several bugs are corrected; no new functionality is added.

3.4 Version 2.1.1 release

Version 2.1.1 adds the following functionality:

1. New signal names and locations when using selected data analysis commands *Signal names, identity and locations (see chapter 3.4.1, page 34)*.
2. Current range logged for all measurement commands *Current range logging (see chapter 3.4.2, page 37)*
3. Event logging for all measurement commands *Event logging (see chapter 3.4.3, page 38)*.
4. Export possibility for Spectrophotometer manual control panel *Export options for Spectrophotometer control panel (see chapter 3.4.4, page 40)*.
5. Step through data option added to the Spectrophotometer manual control panel *Export options for Spectrophotometer control panel (see chapter 3.4.5, page 41)*.
6. A procedure for spectroelectrochemical measurements has been added to the **Default** procedures *Spectroelectrochemistry procedure (see chapter 3.4.6, page 42)*.

3.4.1 Signal names, identity and locations

NOVA 2.1.1 changes the way the following analysis commands work:

- Smooth
- Derivative
- Integrate
- Baseline correction

In previous versions of NOVA, these commands created two result signals regardless of the number of signals in the source data. For example, when using the **Integrate** command in previous versions of NOVA, the calculated signals were called *Integration result X* and *Integration result Y*.

These calculated signals, only available in the analysis command itself, no longer had units or identity.

In NOVA 2.1.1, when either one of these four commands is used on data provided by a parent measurement command, the nature of the signals involved in the analysis command and their units are retained and the resulting signals are duplicated in the original parent measurement command.

For example, applying a **Smooth** command on i vs E data (WE(1).Current vs Potential applied), as shown in *Figure 27*, now produces two new signals called *Smoothed WE(1).Current* and *Potential applied*, as shown in *Figure 28*.

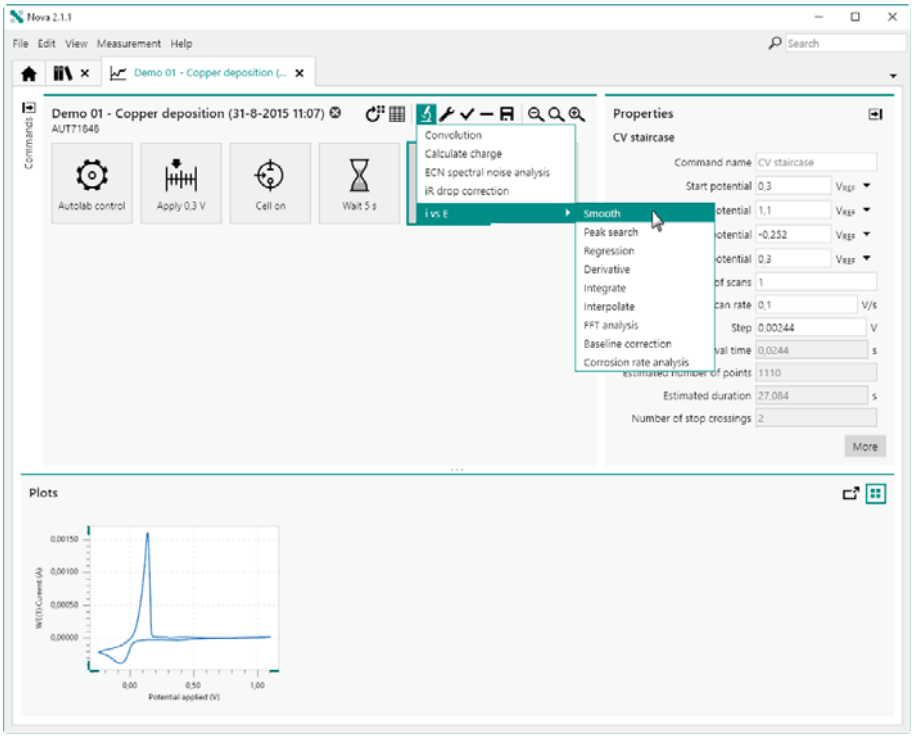


Figure 27 Adding a Smooth command to the i vs E plot

The calculated signals are automatically plotted *(see figure 28, page 36)*.

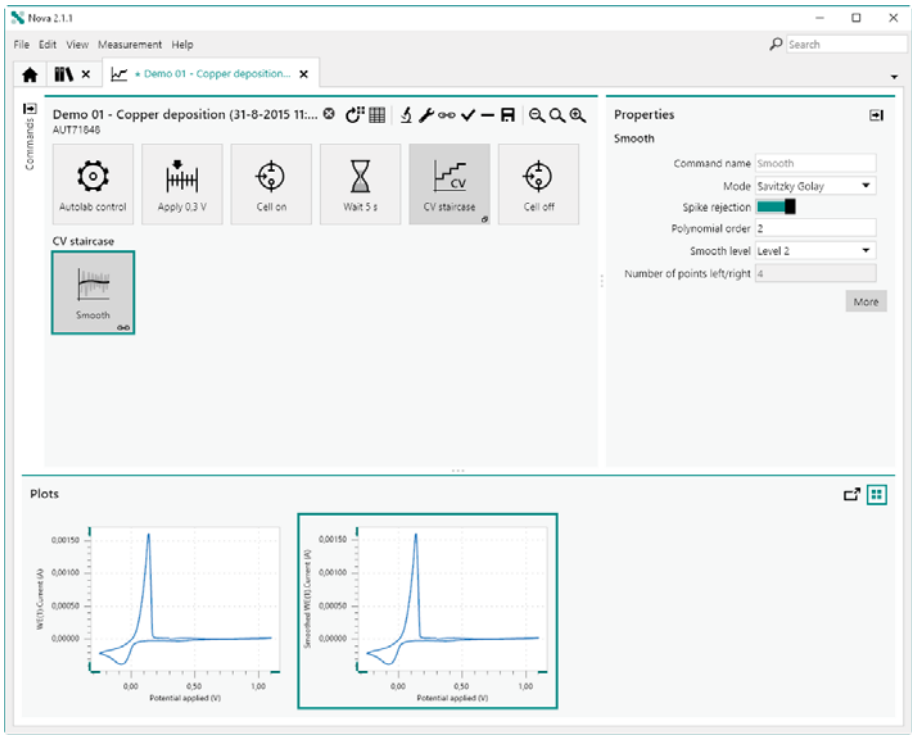


Figure 28 Smoothed WE(1).Current vs Potential applied plot is created

Additionally, the calculated data is copied to the parent measurement command (CV staircase), as shown in *Figure 29*.

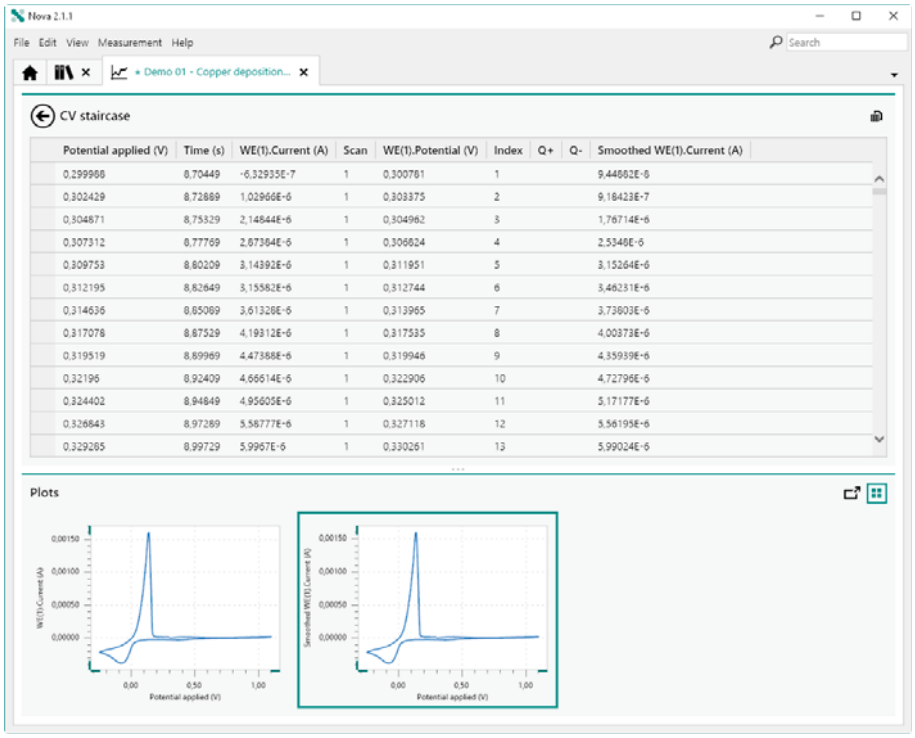


Figure 29 The calculated signals are also available in the parent command

The calculated *Smoothed WE(1).Current* signal is known by the NOVA procedure as a valid current signal, obtained by applying a **Smooth** command on the WE(1).Current signal of the **CV staircase** command.

3.4.2 Current range logging

NOVA 2.1.1 now logs the active current range for each data point recorded in all measurement commands. This information is stored in the data file and is reported in the data grid *(see figure 30, page 37)*.

LSV staircase

Potential applied (V)	Time (s)	WE(1).Current (A)	WE(1).Potential (V)	Index	Current range
0,288086	10,4533	2,86011E-7	0,287781	118	100 nA
0,290527	10,4777	2,88239E-7	0,290253	119	100 nA
0,292969	10,5021	2,97638E-7	0,292664	120	100 nA
0,29541	10,5265	2,98279E-7	0,295074	121	100 nA
0,297852	10,5509	2,96173E-7	0,297607	122	100 nA
0,300293	10,5753	2,99164E-7	0,299957	123	100 nA
0,302734	10,5997	3,02643E-7	0,302338	124	100 nA
0,305176	10,6241	3,08868E-7	0,305298	125	1 µA
0,307617	10,6485	3,0954E-7	0,30777	126	1 µA
0,310059	10,6729	3,07281E-7	0,310394	127	1 µA
0,3125	10,6973	3,1076E-7	0,312897	128	1 µA
0,314941	10,7217	3,21289E-7	0,315277	129	1 µA
0,317383	10,7461	3,21442E-7	0,317657	130	1 µA
0,319824	10,7705	3,18298E-7	0,32016	131	1 µA
0,322266	10,7949	3,19824E-7	0,322601	132	1 µA

Figure 30 The active current range is now reported in the data grid

NOTICE

This new feature only applies to measurements carried out with NOVA 2.1.1 or later. Measurements carried out with earlier versions of NOVA may not display the active current range properly.

NOTICE

More information on current range logging is available in *Chapter 11.9.1*.

3.4.3 Event logging

NOVA 2.1.1 now logs events taking place during measurement commands. These events are logged alongside the measured data points and are stored in the data file. Whenever possible, the events are associated to a measured data point. The following events are now logged and stored:

- **Overloads:** these events correspond to situations where a current, voltage or temperature overload was detected during a measurement.
- **Cutoffs:** these events correspond to situations where a cutoff condition is met.
- **Counters:** these events correspond to situations where a counter is activated.
- **User events:** these events correspond to situations where the user changed a measurement property during a measurement or used a flow control option (stop, pause, reverse scan direction) provided by NOVA.

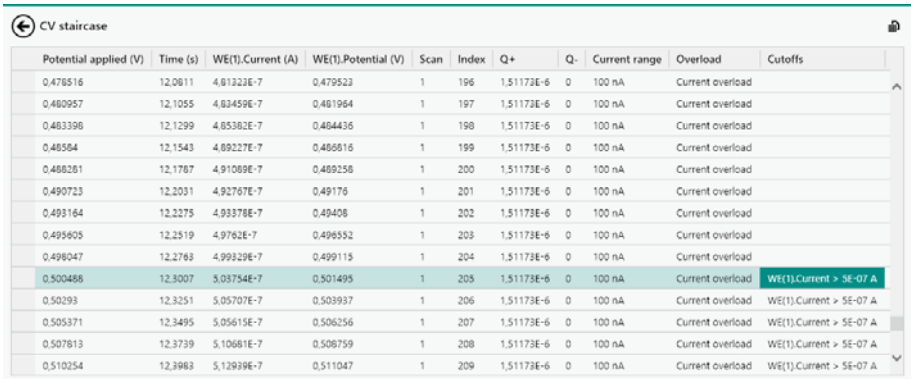
When these events are detected, they are reported in the data grid, as shown in *Figure 31*.

CV staircase

Potential applied (V)	Time (s)	WE(1).Current (A)	WE(1).Potential (V)	Scan	Index	Q+	Q-	Current range	Overload
0,0244141	8,24948	2,68005E-6	0,025705	1	10	1,90342E-6	-1,89706E-6	10 nA	
0,0268555	8,27383	2,64973E-6	0,0281555	1	11	1,90342E-6	-1,89706E-6	10 nA	
0,0292969	8,29823	3,13751E-6	0,0306	1	12	1,90342E-6	-1,89706E-6	10 nA	
0,0317383	8,32263	3,16864E-6	0,0330383	1	13	1,90342E-6	-1,89706E-6	10 nA	
0,0341797	8,34703	3,55682E-6	0,0355286	1	14	1,90342E-6	-1,89706E-6	10 nA	
0,0366211	8,37143	3,83942E-6	0,0378967	1	15	1,90342E-6	-1,89706E-6	10 nA	Current overload
0,0390625	8,39583	4,24744E-6	0,0403625	1	16	1,90342E-6	-1,89706E-6	10 nA	Current overload
0,0415039	8,42023	4,45251E-6	0,0428436	1	17	1,90342E-6	-1,89706E-6	10 nA	Current overload
0,0439453	8,44463	4,36507E-6	0,0452057	1	18	1,90342E-6	-1,89706E-6	10 nA	Current overload
0,0463867	8,46903	4,71663E-6	0,0476027	1	19	1,90342E-6	-1,89706E-6	10 nA	Current overload
0,0488281	8,49343	5,1889E-6	0,0501099	1	20	1,90342E-6	-1,89706E-6	10 nA	Current overload
0,0512695	8,51783	5,44586E-6	0,0526733	1	21	1,90342E-6	-1,89706E-6	10 nA	Current overload
0,0537109	8,54223	5,65277E-6	0,0552063	1	22	1,90342E-6	-1,89706E-6	10 nA	Current overload
0,0561523	8,56663	5,72449E-6	0,0575867	1	23	1,90342E-6	-1,89706E-6	10 nA	Current overload

Figure 31 Events are logged in the data grid

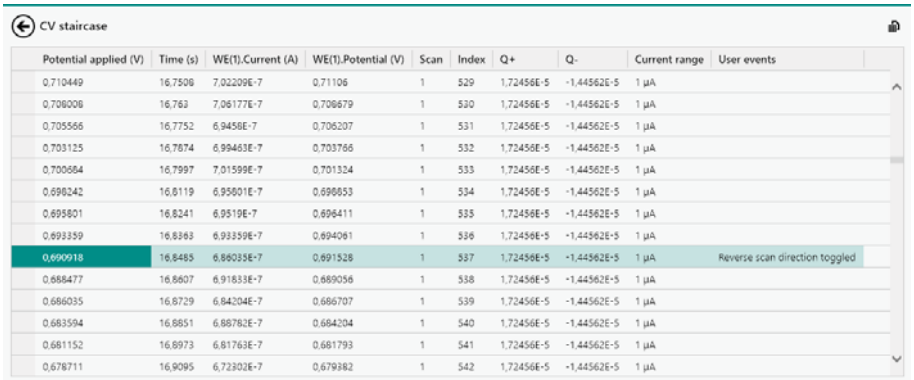
Depending on the type of event, more or less information may be reported in the data grid. In the case of a cutoff condition, information about the signal and value is reported in the data grid *(see figure 32, page 39)*.


CV staircase

Potential applied (V)	Time (s)	WE(1).Current (A)	WE(1).Potential (V)	Scan	Index	Q+	Q-	Current range	Overload	Cutoffs
0,478516	12,0611	4,81323E-7	0,479523	1	196	1,51173E-6	0	100 nA	Current overload	
0,480957	12,1055	4,83459E-7	0,481964	1	197	1,51173E-6	0	100 nA	Current overload	
0,483398	12,1299	4,85382E-7	0,484436	1	198	1,51173E-6	0	100 nA	Current overload	
0,48584	12,1543	4,89227E-7	0,486616	1	199	1,51173E-6	0	100 nA	Current overload	
0,488281	12,1787	4,91089E-7	0,489258	1	200	1,51173E-6	0	100 nA	Current overload	
0,490723	12,2031	4,92767E-7	0,49176	1	201	1,51173E-6	0	100 nA	Current overload	
0,493164	12,2275	4,93378E-7	0,49408	1	202	1,51173E-6	0	100 nA	Current overload	
0,495605	12,2519	4,9762E-7	0,496552	1	203	1,51173E-6	0	100 nA	Current overload	
0,498047	12,2763	4,99329E-7	0,499115	1	204	1,51173E-6	0	100 nA	Current overload	
0,500488	12,3007	5,03754E-7	0,501495	1	205	1,51173E-6	0	100 nA	Current overload	WE(1).Current > 5E-07 A
0,50293	12,3251	5,05707E-7	0,503937	1	206	1,51173E-6	0	100 nA	Current overload	WE(1).Current > 5E-07 A
0,505371	12,3495	5,05615E-7	0,506256	1	207	1,51173E-6	0	100 nA	Current overload	WE(1).Current > 5E-07 A
0,507813	12,3739	5,10681E-7	0,508759	1	208	1,51173E-6	0	100 nA	Current overload	WE(1).Current > 5E-07 A
0,510254	12,3983	5,12939E-7	0,511047	1	209	1,51173E-6	0	100 nA	Current overload	WE(1).Current > 5E-07 A

Figure 32 The details of the cutoff condition are reported in the data grid

The same applies to user intervention, where the action performed by the user is reported in the grid *(see figure 33, page 39)*.


CV staircase

Potential applied (V)	Time (s)	WE(1).Current (A)	WE(1).Potential (V)	Scan	Index	Q+	Q-	Current range	User events
0,710449	16,7508	7,02209E-7	0,71106	1	529	1,72456E-5	-1,44562E-5	1 µA	
0,708008	16,763	7,06177E-7	0,708679	1	530	1,72456E-5	-1,44562E-5	1 µA	
0,705566	16,7752	6,9458E-7	0,706207	1	531	1,72456E-5	-1,44562E-5	1 µA	
0,703125	16,7874	6,99463E-7	0,703766	1	532	1,72456E-5	-1,44562E-5	1 µA	
0,700684	16,7997	7,01599E-7	0,701324	1	533	1,72456E-5	-1,44562E-5	1 µA	
0,698242	16,8119	6,95601E-7	0,698653	1	534	1,72456E-5	-1,44562E-5	1 µA	
0,695801	16,8241	6,9519E-7	0,696411	1	535	1,72456E-5	-1,44562E-5	1 µA	
0,693359	16,8363	6,93359E-7	0,694061	1	536	1,72456E-5	-1,44562E-5	1 µA	
0,690918	16,8485	6,86035E-7	0,691528	1	537	1,72456E-5	-1,44562E-5	1 µA	Reverse scan direction toggled
0,688477	16,8607	6,91833E-7	0,689056	1	538	1,72456E-5	-1,44562E-5	1 µA	
0,686035	16,8729	6,84204E-7	0,686707	1	539	1,72456E-5	-1,44562E-5	1 µA	
0,683594	16,8851	6,88782E-7	0,684204	1	540	1,72456E-5	-1,44562E-5	1 µA	
0,681152	16,8973	6,81763E-7	0,681793	1	541	1,72456E-5	-1,44562E-5	1 µA	
0,678711	16,9095	6,72302E-7	0,679382	1	542	1,72456E-5	-1,44562E-5	1 µA	

Figure 33 User events are reported in the data grid

NOTICE

This new feature only applies to measurements carried out with NOVA 2.1.1 or later. Measurements carried out with earlier versions of NOVA may not display the recorded events properly.

NOTICE

More information on event logging is available in *Chapter 11.9.2*.

Furthermore, NOVA now provides indications whenever the measurement conditions can be improved, by highlighting the affected command in blue in the procedure editor *(see figure 34, page 40)*.

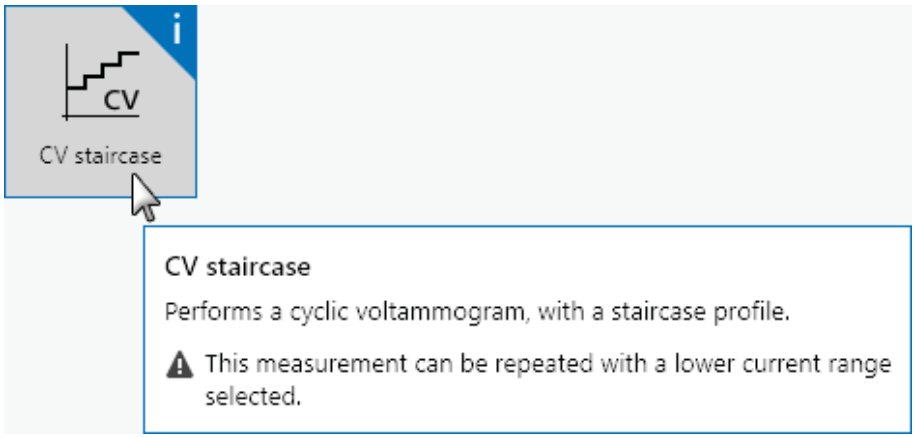


Figure 34 Commands are highlighted in blue when the measurement conditions can be improved

3.4.4 Export options for Spectrophotometer control panel

NOVA 2.1.1 adds the possibility to export data measured in the **Spectrophotometer** control panel. The data can be exported to ASCII or Excel using the button located in the top right corner of the control panel *(see figure 35, page 40)*.

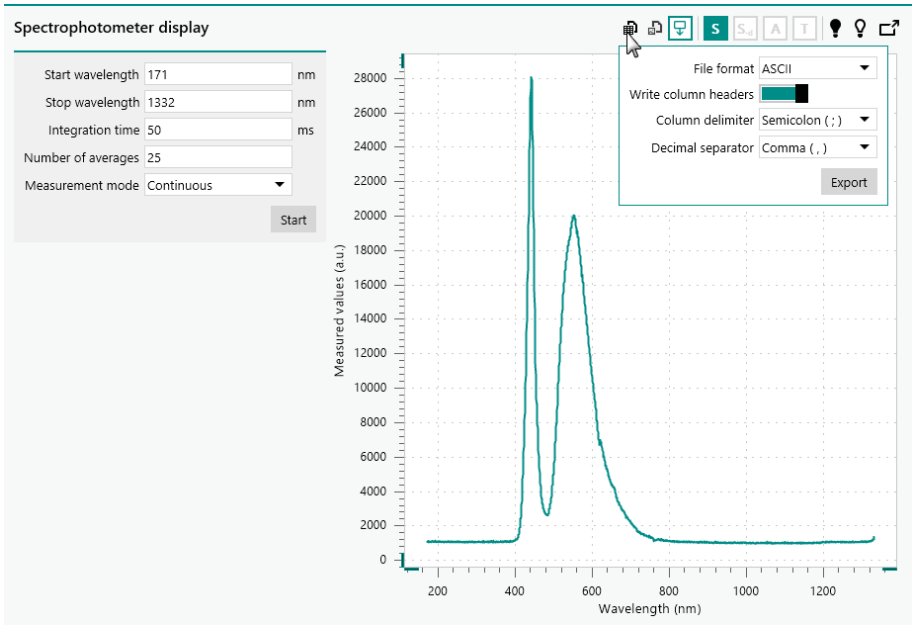


Figure 35 The measured data can be exported to ASCII or Excel

It is also possible to export the chart displayed in the **Spectrophotometer** control panel using the button, as shown in *Figure 36*.

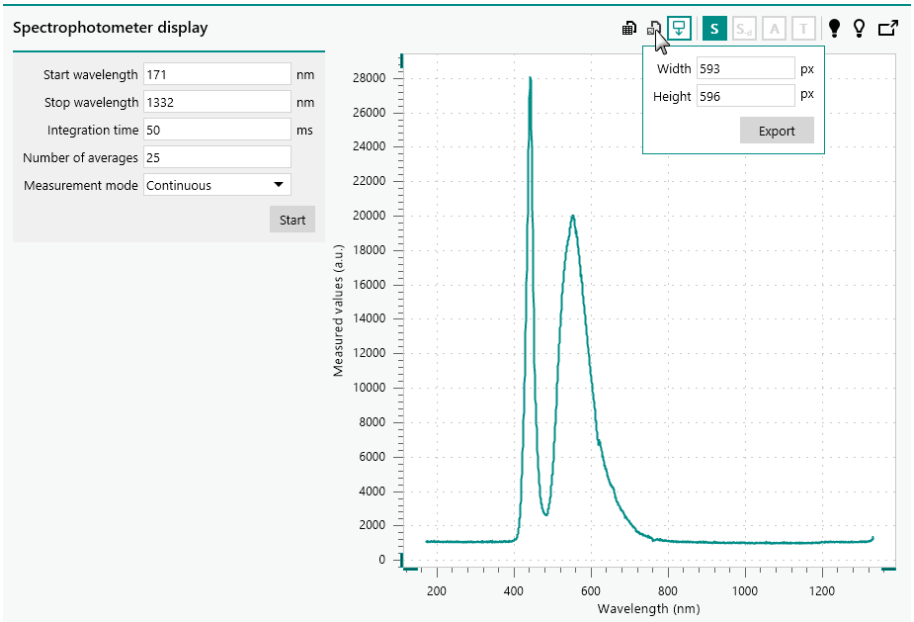


Figure 36 The chart can also be exported

NOTICE

More information on the manual control of the Autolab and Avantes spectrophotometers can be found in *Chapter 5.4*.

3.4.5 Export options for Spectrophotometer control panel

NOVA 2.1.1 adds the possibility to toggle the *Step through data* option on or off in the Spectrophotometer control panel using the button in the top right corner of the control panel *(see figure 37, page 42)*.

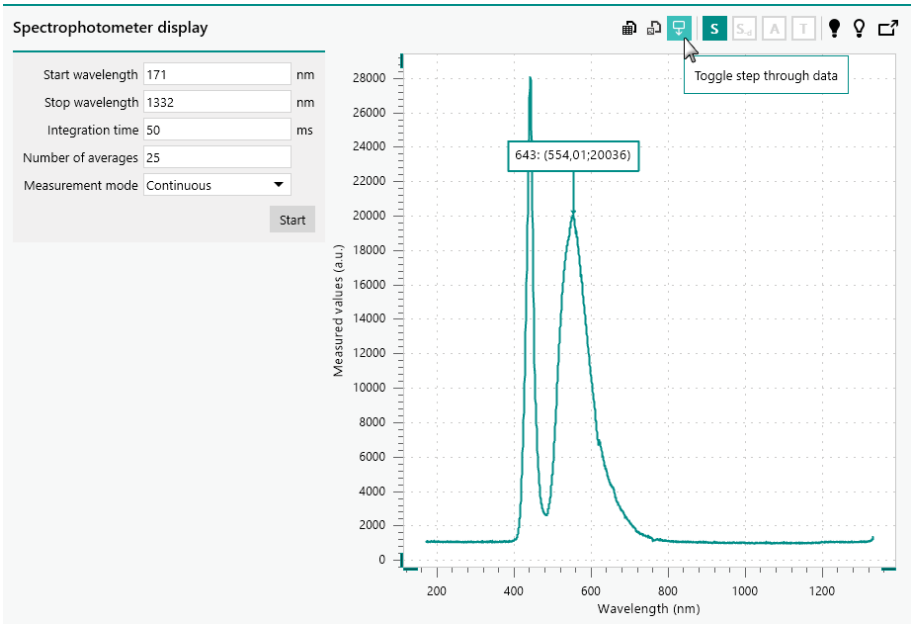


Figure 37 The Step through data option can be used in the Spectrophotometer control panel

When the *Step through data* mode is on, an additional indicator is added to the plot, showing the X and Y coordinates of the point indicated by the arrow. The indicator can be relocated anywhere in the plot area.

NOTICE

More information on the manual control of the Autolab and Avantes spectrophotometers can be found in *Chapter 5.4*.

3.4.6 Spectroelectrochemistry procedure

A procedure for spectroelectrochemical measurements in combination with support spectrophotometers has been added to the **Default procedures**. This procedure is based on a synchronized measurement, using a **LSV staircase** command. The procedure is shown in *Figure 38*.

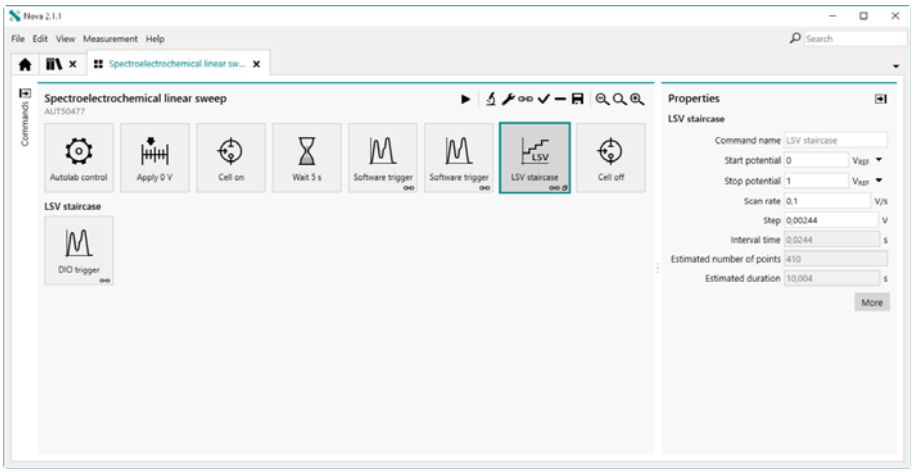


Figure 38 The default procedure for spectroelectrochemical measurements

This procedure includes a counter that is used to trigger a spectroscopy measurement every points. The **Spectroscopy** command stacked on the **LSV staircase** command uses the data from the two preceding **Spectroscopy** commands to calculate the absorbance and transmittance automatically.

CAUTION

This procedure requires an Autolab spectrophotometer or a supported Avantes spectrophotometer.

NOTICE

More information on this procedure can be found in *Chapter 8*.

3.5 Version 2.1 release

Version 2.1 adds the following functionality:

1. Application-wide search function for Procedures, Data and Schedules *Search function (see chapter 3.5.1, page 44)*.
2. Check cell tool *Check cell (see chapter 3.5.2, page 46)*.
3. Cell off after current interrupt *Current interrupt (see chapter 3.5.3, page 46)*.
4. Manual control for Autolab and Avantes spectrophotometers *Spectrophotometer manual control (see chapter 3.5.4, page 47)*.
5. New command and command options for spectroelectrochemical applications *Spectroelectrochemical measurements (see chapter 3.5.5, page 48)*.
6. Repeat number added to **Repeat** command *Repeat number in Repeat command (see chapter 3.5.6, page 50)*.
7. Custom names for commands *Custom command name (see chapter 3.5.7, page 51)*.
8. Zoom function for procedure editor and schedule editor *Zoom function (see chapter 3.5.8, page 52)*.
9. New Electrochemical Frequency Modulation (EFM) measurement command available *Electrochemical Frequency Modulation (see chapter 3.5.9, page 53)*.
10. Corrosion rate analysis command expanded with Linear polarization analysis mode *Corrosion rate analysis (see chapter 3.5.10, page 54)*.
11. Improved **Plot** frame controls *New Plots frame controls (see chapter 3.5.11, page 55)*.
12. All device drivers are now included in the NOVA installer *Device drivers installation (see chapter 3.5.12, page 57)*

3.5.1 Search function

NOVA now provides the possibility to search for Procedures, Data or Schedules. A dedicated input field is located in the top right corner of the application *(see figure 39, page 45)*.

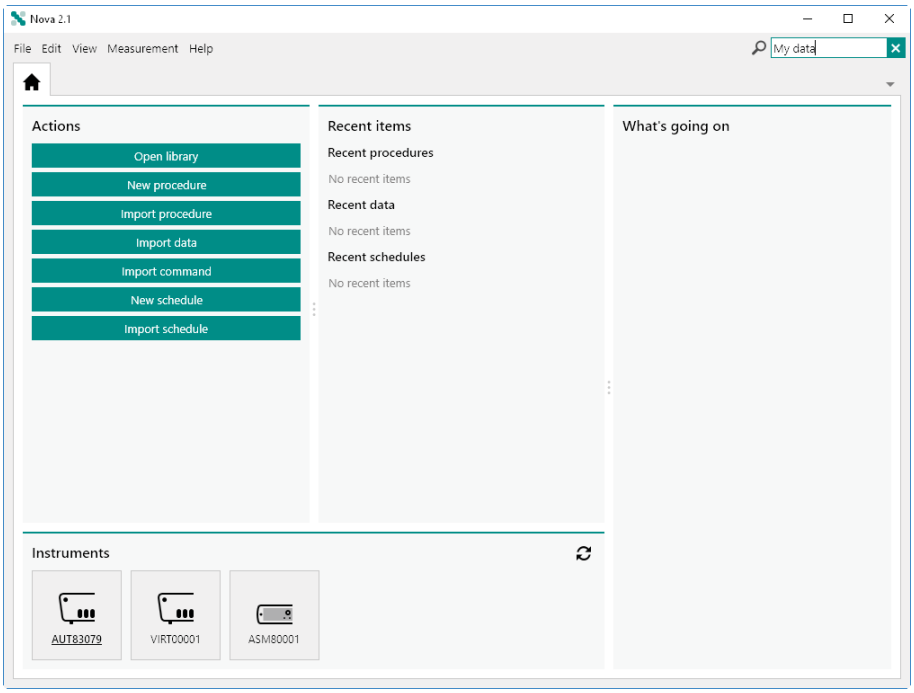


Figure 39 A search box is provided in the top right corner

The search function can be used to specify a string, with or without wild-cards. When triggered, the search function will look for all Procedures, Data and Schedule items in all the *Locations* specified in the **Library**, except the Default procedures.

The results of the search will be reported in a dedicated tab, grouped by item type. The table controls used to display the results are the same as those used by the **Library**. The results can therefore be sorted or filtered as required.

NOTICE

The search function will look for all items that match the specified search string in the Name or Remarks.

NOTICE

More information on the search function can be found in *Chapter 6.18*.

3.5.2 Check cell

The Check cell tool is now available from the instrument control panel. This tool can be used to check the electrode connections and the noise level by performing five consecutive current or potential measurements and determining the average value and standard deviation of each measurement *(see figure 40, page 46)*.

Figure 40 The Check cell tool can now be used to check the noise level

The tool can therefore be used to assess the instrument noise pickup and optimize the measurement conditions.

NOTICE

More information on the **Check cell** tool can be found in *Chapter 5.2.2.4*.

3.5.3 Current interrupt

The current interrupt tool has been modified and now allows the possibility to switch the cell off at the end of the measurement *(see figure 41, page 47)*.

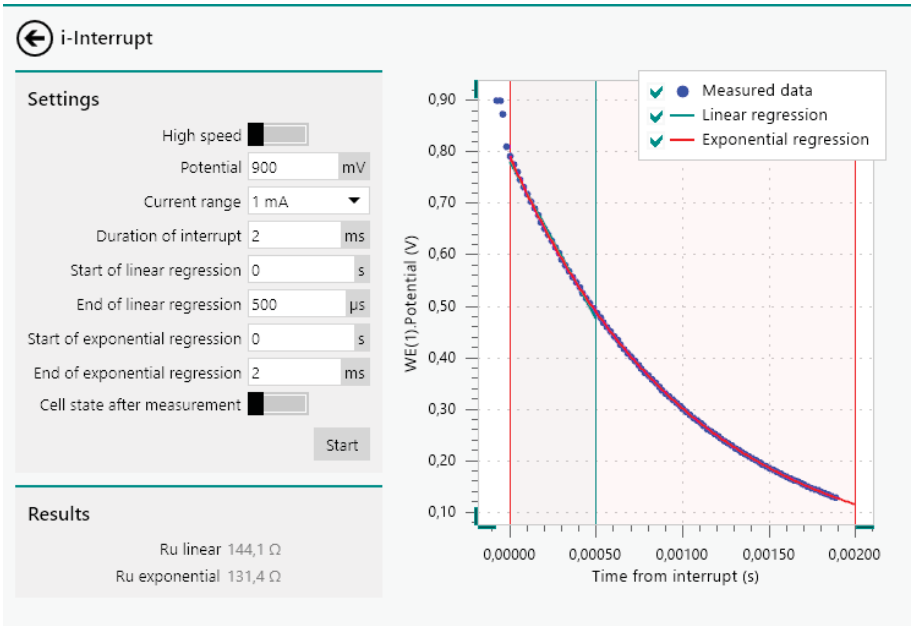


Figure 41 The current interrupt tool now provides the possibility to set the cell end state

The *Cell state after measurement* toggle, located in the **Settings** panel, can be used to specify the state of the cell at the end of the measurement. This toggle in off by default.

NOTICE

More information on the current interrupt tool can be found in *Chapter 5.2.2.2*.

3.5.4 Spectrophotometer manual control

NOVA now provides a complete manual control interface for Autolab and Avantes spectrometers. This interface can be used to setup the hardware configuration of the connected spectrophotometer and manually control the spectrophotometer *(see figure 42, page 48)*.

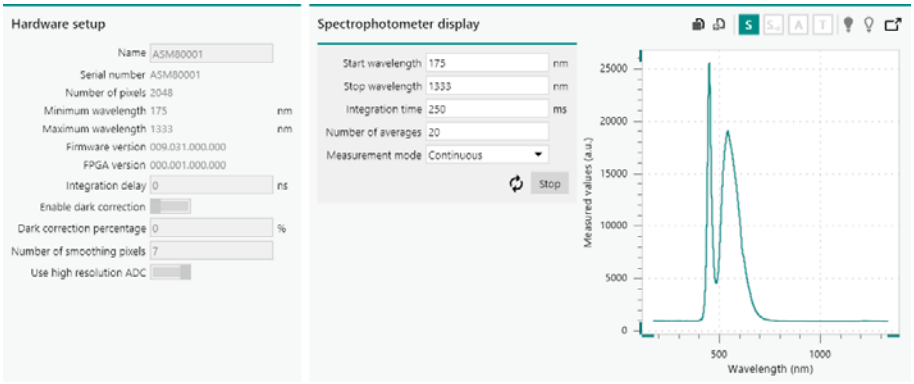


Figure 42 Autolab and Avantes spectrophotometers can be manually controlled

Using this interface it is possible to acquire spectra using the specified properties. It is also possible to save measured spectra as dark and reference (blank) spectra and convert the measured data to absorbance, transmittance or reflectance.

NOTICE

More information on the manual control of the Autolab and Avantes spectrophotometers can be found in *Chapter 5.4*.

3.5.5 Spectroelectrochemical measurements

New measurement command and command options have been added to NOVA in order to facilitate spectroelectrochemical measurements. The **Avantes** command is now replaced with the **Spectroscopy** command, which can be used to control Autolab (and Avantes) spectrophotometers.

It is no longer necessary to initialize and close this type of device in a procedure and the new **Spectroscopy** command now supports a software acquisition mode, which can be used at any time without triggers *(see figure 43, page 49)*.

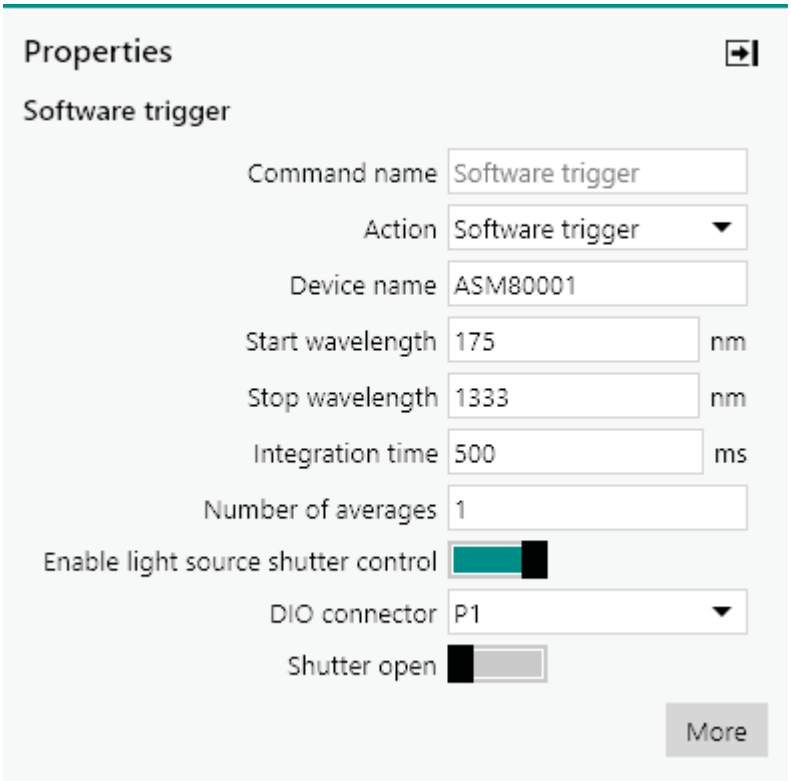


Figure 43 Software and hardware control is now possible to Autolab and Avantes spectrophotometers

New measurement options are available for all measurement commands that support them. These option can be used to control the light source shutter position or to acquire a spectrum on the spectrophotometer connected to the DIO port *(see figure 44, page 50)*.

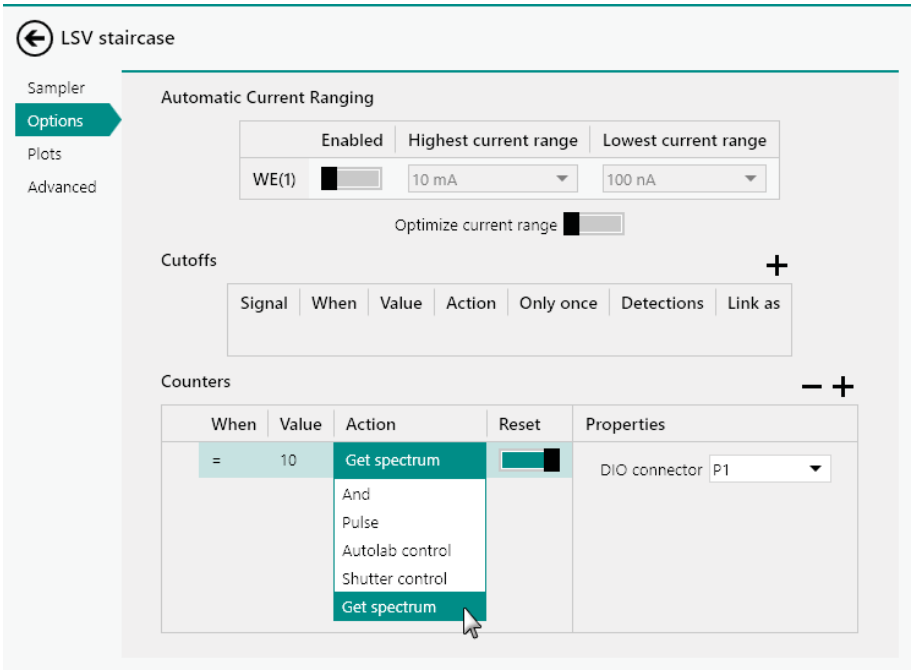


Figure 44 New control options are available for measurement commands

NOTICE

More information on the **Spectroscopy** command and the spectrophotometer control options are available in *Chapter 7.11.1* and *Chapter 9*, respectively.

3.5.6 Repeat number in Repeat command

The **Repeat** command now provides a new signal, Repetition number, that can be used in combination with other commands. This new signal is a single value that is incremented at the beginning of each repetition *(see figure 45, page 51)*.

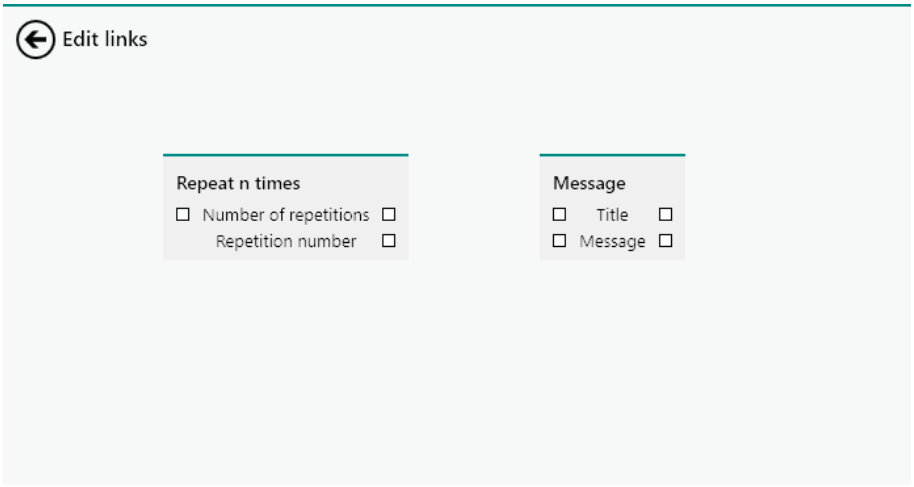


Figure 45 The Repetition number is now available in the Repeat command

NOTICE

More information on the Repeat command can be found in *Chapter 7.1.3*.

3.5.7 Custom command name

For improved readability in the procedure editor, it is now possible to specify a name for all commands in a procedure. Providing a custom name will overrule the default name of the command *(see figure 46, page 52)*.

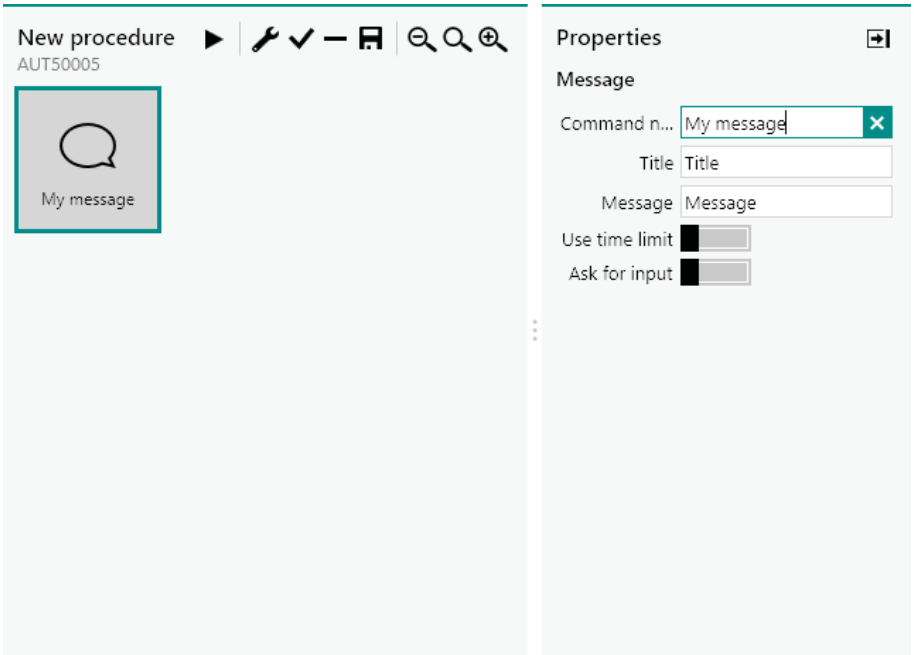


Figure 46 Custom names can now be given to all commands

NOTICE

When a custom name is provided for a command, the content of this command is no longer updated during a measurement, if applicable.

3.5.8 Zoom function

The procedure editor and the schedule editor now offer the possibility to zoom in or out at any time to increase or decrease the size of the items shown on screen. The controls for this new zoom function are located in the top right corner of the editor frame *(see figure 47, page 52)*.

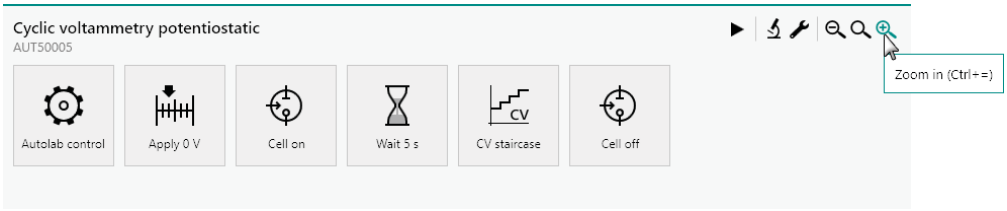


Figure 47 Zoom controls are now available

Using this function will either scale the size of the items and the text up or down (between 200 % and 50 % of the original size), as shown in *Figure 48*.

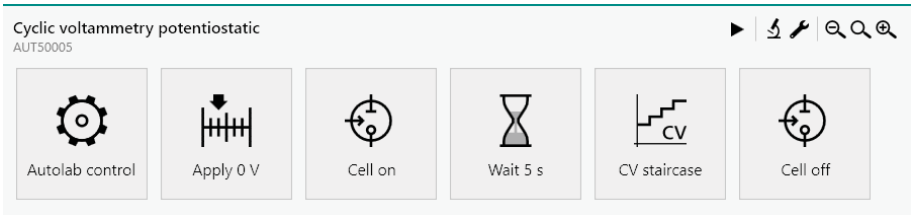


Figure 48 Zooming in on the procedure editor

The following zooming controls are available:

- **Zoom out:** decreases the scaling of the items and text shown on screen. The button or **[CTRL]** + **[-]** keyboard shortcut can be used to do this.
- **Zoom to 100%:** resets the scaling of the items and text shown on screen to the default size. The button or **[F4]** keyboard shortcut can be used to do this.
- **Zoom in:** increases the scaling of the items and text shown on screen. The button or **[CTRL]** + **[=]** keyboard shortcut can be used to do this.

NOTICE

More information on the zoom controls of the procedure editor and the schedule editor can be found in *Chapter 10.6* and *Chapter 15.7*, respectively.

3.5.9 Electrochemical Frequency Modulation

This version of NOVA provides support for Electrochemical Frequency Modulation (EFM) measurements. These measurements are based on the application of a small amplitude voltage perturbation and recording of the electrochemical response of the cell. Using the measured data, corrosion rate information can be determined.

EFM measurements use a special two component sinewave modulation. During this type of measurements, the response from the cell at the applied frequency, higher harmonics of these frequencies and intermodulated frequencies are recorded. *Figure 49* shows a typical measurement.

Figure 49 Example of an EFM measurement

CAUTION

Electrochemical Frequency Modulation measurements require a **FRA32M** module.

NOTICE

More information on Electrochemical Frequency Modulation command can be found in *Chapter 7.6.4*.

3.5.10 Corrosion rate analysis

The **Corrosion rate analysis** command has been complemented with a new mode: **Polarization Resistance**. This analysis method is based on the **ASTM G59** standard and it uses the *Stern-Geary* equation to determine the corrosion current and the corrosion rate *(see figure 50, page 55)*.

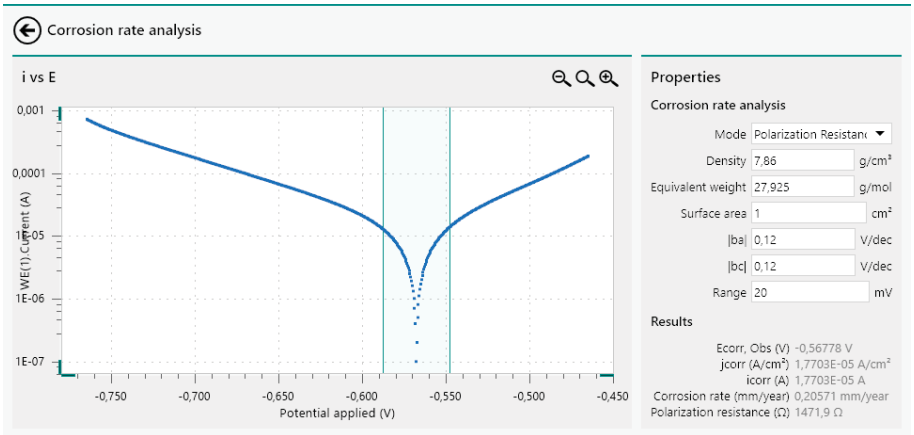


Figure 50 The Linear polarization method has been added to the Corrosion rate analysis command

Provided that the analysis is carried out in a low overpotential range with respect to the corrosion potential, the Linear polarization analysis method can provide a direct estimation of the corrosion current and corrosion rate, using user-defined Tafel slopes.

NOTICE

More information on the **Corrosion rate analysis** command can be found in *Chapter 7.8.14*.

3.5.11 New Plots frame controls

The **Plots** frame now provides new controls that can be used to disable plots *(see figure 51, page 56)*.

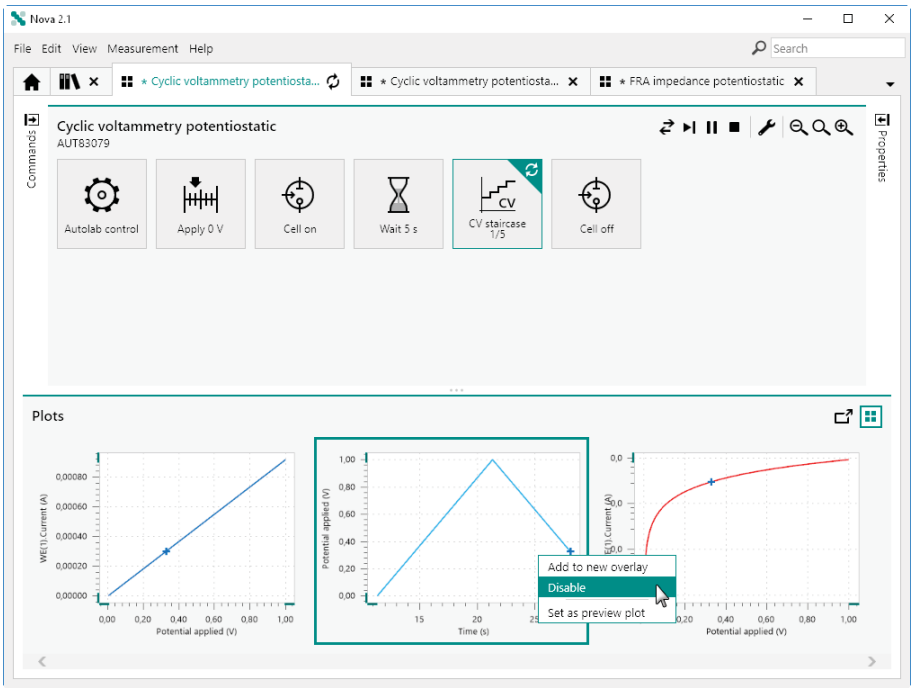


Figure 51 Disabling plots in the Plots frame

NOTICE

Disabling plots can be done at any time.

It is also now possible to relocate the plot order or overlay plots by dragging the plots in the frame *(see figure 52, page 57)*.

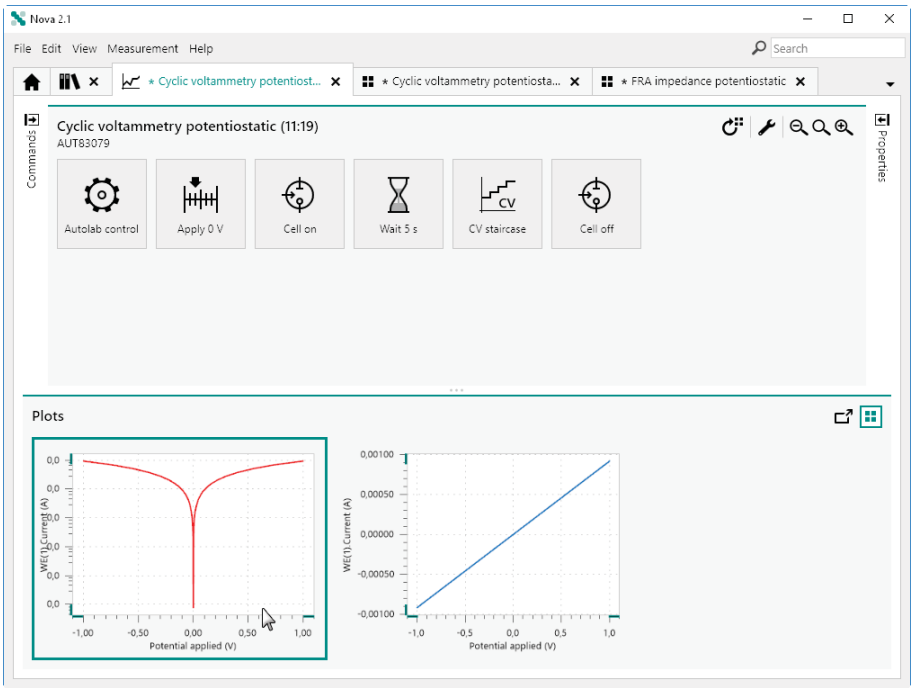


Figure 52 Rearranging the plot order

NOTICE

It is not possible to relocate plot during a measurement.

NOTICE

More information on the disabling of plots and the relocation of plots can be found in *Chapter 11.5.5* and *Chapter 11.8.8*, respectively.

3.5.12 Device drivers installation

The installation package of NOVA 2.1 now installs all required device drivers during the installation process, as described in *Chapter 1.3*.

The following drivers are installed:

- **Autolab device drivers:** required for using the Autolab potentiostat/galvanostat.
- **Metrohm device driver:** required for using any supported Metrohm liquid handling instrument.
- **Spectrophotometer device driver:** required for using any supported Autolab (or Avantes) spectrophotometer.

NOTICE

If needed, the **Driver manager** application can be used to change the driver used to control the Autolab potentiostat/galvanostat as described in *Chapter 1.6*.

3.6 Version 2.0.2 release

Version 2.0.2 adds the following functionality:

1. Managed schedules *Managed schedules (see chapter 3.6.1, page 58)*.
2. Plot color picker *New color picker (see chapter 3.6.2, page 60)*.
3. Data handling tools shortcut button *Data handling command shortcut button (see chapter 3.6.3, page 61)*.
4. Filters in **Library** *Library filters (see chapter 3.6.4, page 62)*.
5. Detailed **Sampler** information *Extended Sampler information (see chapter 3.6.5, page 63)*.
6. Zoom function for data analysis commands *Zoom function for data analysis commands (see chapter 3.6.6, page 64)*.
7. Extension to the **Build signal** command *Custom name for Build signal command (see chapter 3.6.7, page 65)*.

3.6.1 Managed schedules

Schedules can now be managed through the **Library** in the same way as procedures and data. The **Library** now provides a default location for **Schedules**, as shown in *Figure 53*, and additional **Locations** can be added if needed.

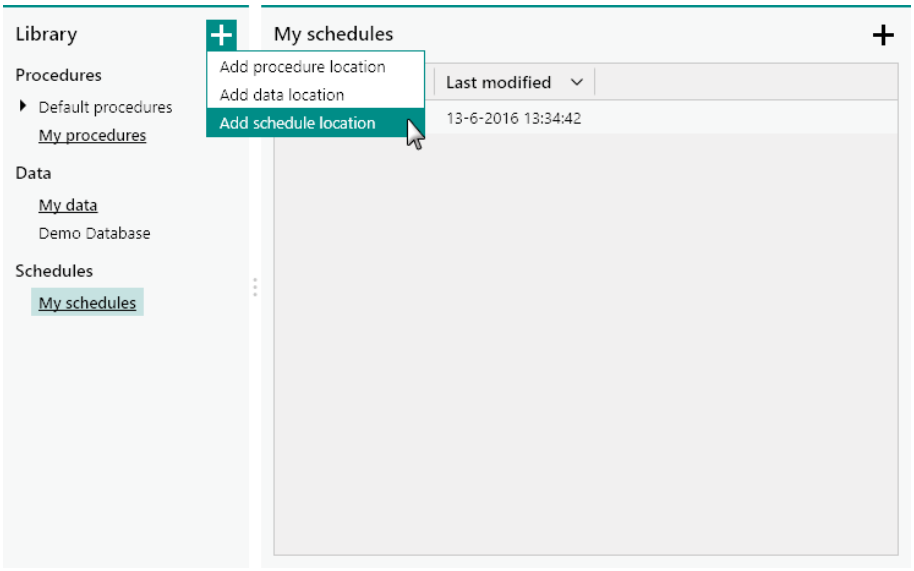


Figure 53 Schedules are now managed through the Library

The most recent **Schedules** are now also listed in the **Recent items** panel on the **Dashboard**, as shown in *Figure 54*.

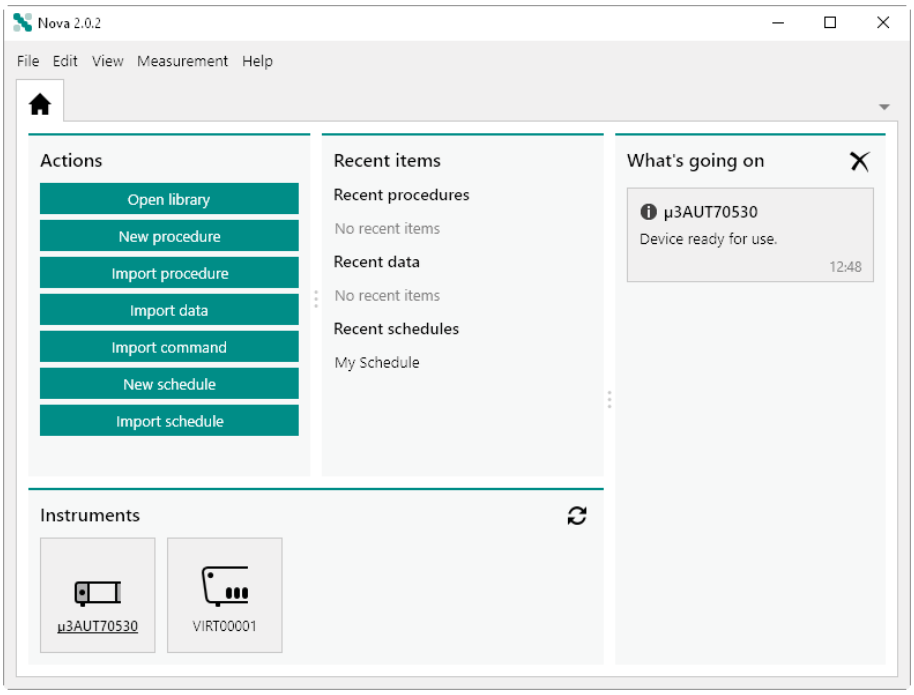


Figure 54 The most recent Schedules are now listed in the Recent items panel

NOTICE

More information on the **Library** can be found in *Chapter 6*.

3.6.2 New color picker

To simplify the editing of plots, the existing color picker of NOVA 2.0 has been replaced with a new version shown in *Figure 55*.

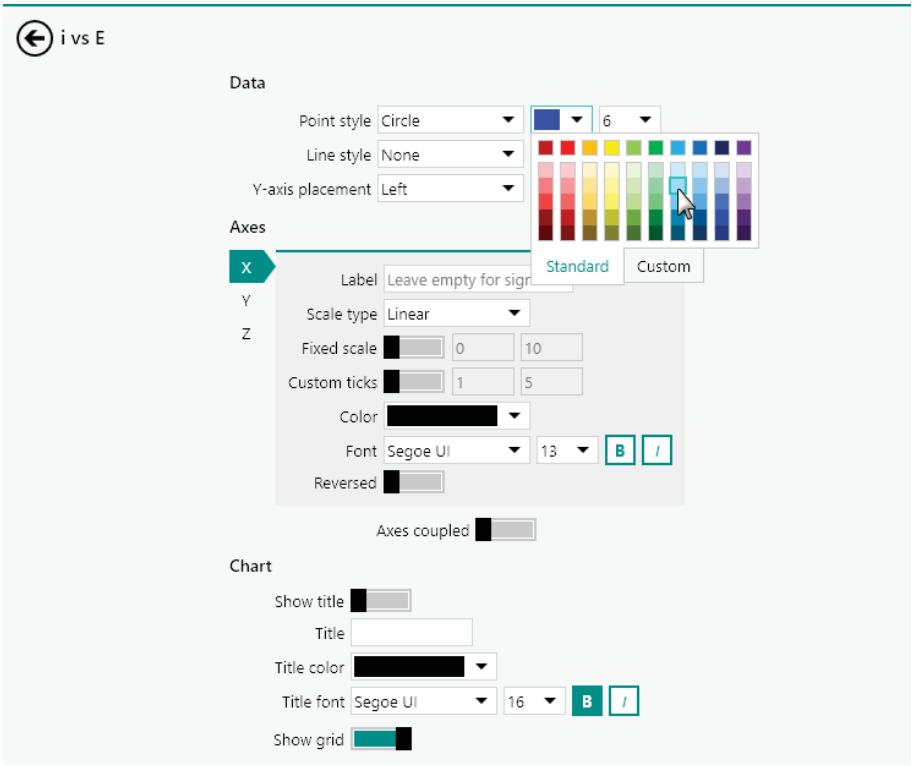


Figure 55 A new color picker is now available

The new color picker provides a list of default colors to choose from. Alternatively, it is possible to define a custom color using the controls provided in the Custom tab *(see figure 56, page 61)*.

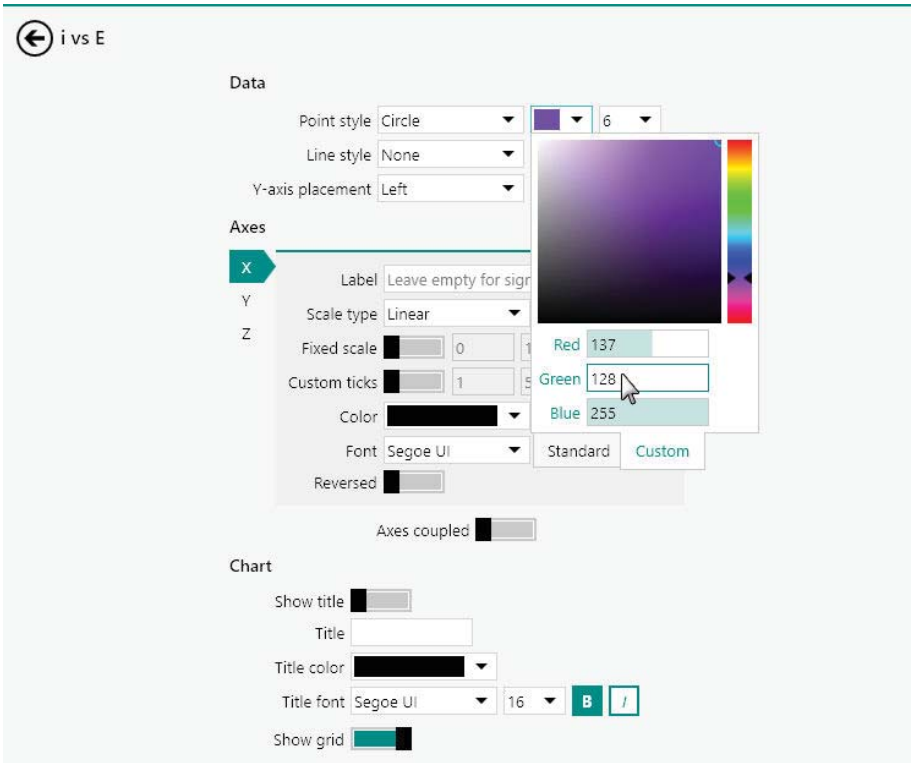


Figure 56 The Custom tab provides additional controls for specifying the color

On the Custom tab, colors can be specified using RGB values or by changing the hue of the selected color or by selecting any available color in the provide RGB color matrix.

3.6.3 Data handling command shortcut button

A shortcut button has been added to this version of NOVA allowing data handling commands to be added to a procedure or data. The shortcut button, located in the top right corner of the procedure editor, works in the same way as the data analysis shortcut button already available in the NOVA *(see figure 57, page 62)*.

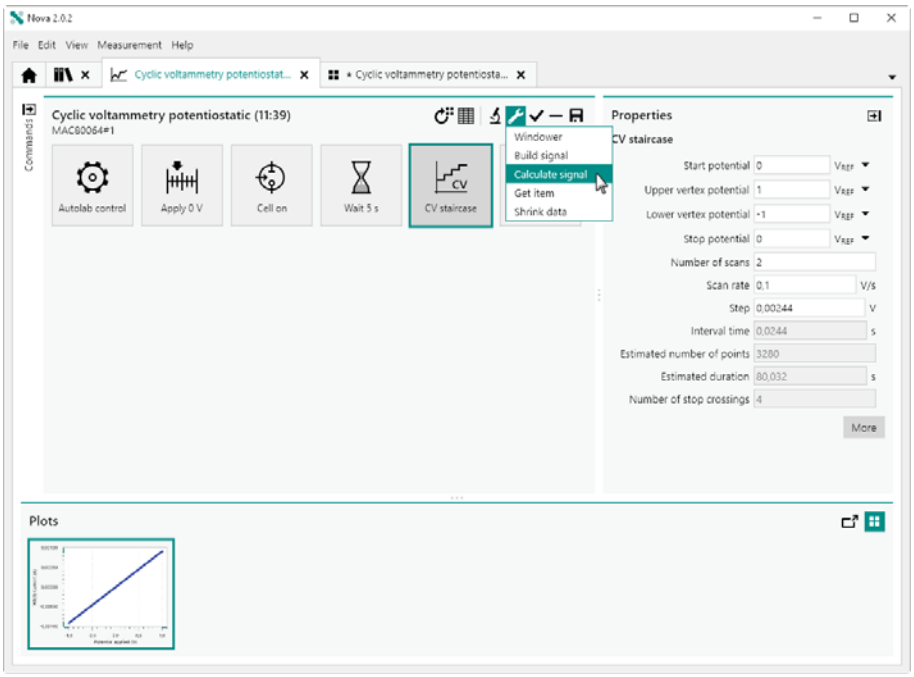


Figure 57 The data handling shortcut button can be used to add data handling commands easily

NOTICE

The data handling commands shown in the popout menu depend on the selected command.

NOTICE

More information on the use of the data handling shortcut button can be found in *Chapter 13*.

3.6.4 Library filters

To facility data management, the **Library** now provides filtering options that can be used to force the **Library** to display items that fit within the specified filter conditions. *Figure 58* shows an example using two filter conditions, one on the instrument serial number and one on the rating.

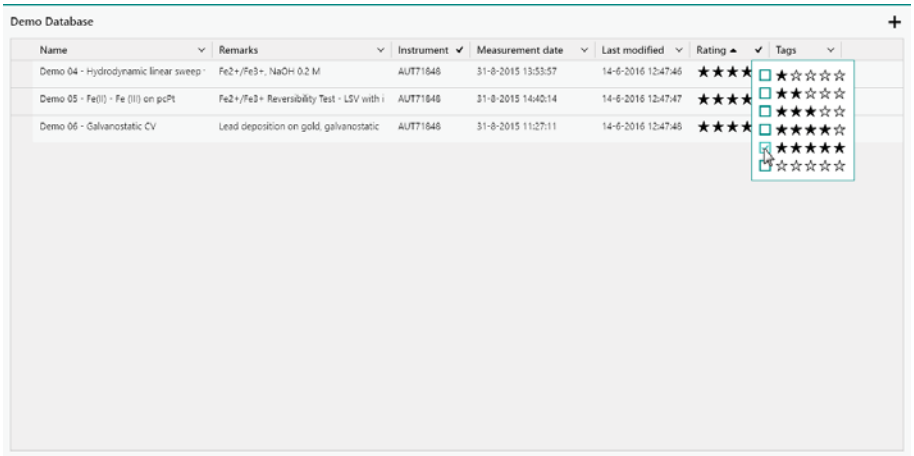


Figure 58 The Library now provides filtering options for better data handling

NOTICE

More information on the **Library** filters can be found in *Chapter 6.11*.

3.6.5 Extended Sampler information

To provide more information on how and when the **Sampler** records the signals during any electrochemical measurement, the **Sampler** editor has been extended with a table that provides more details on the sampling conditions. In the **Sampler** editor, shown in *Figure 59*, an additional More button is now available.

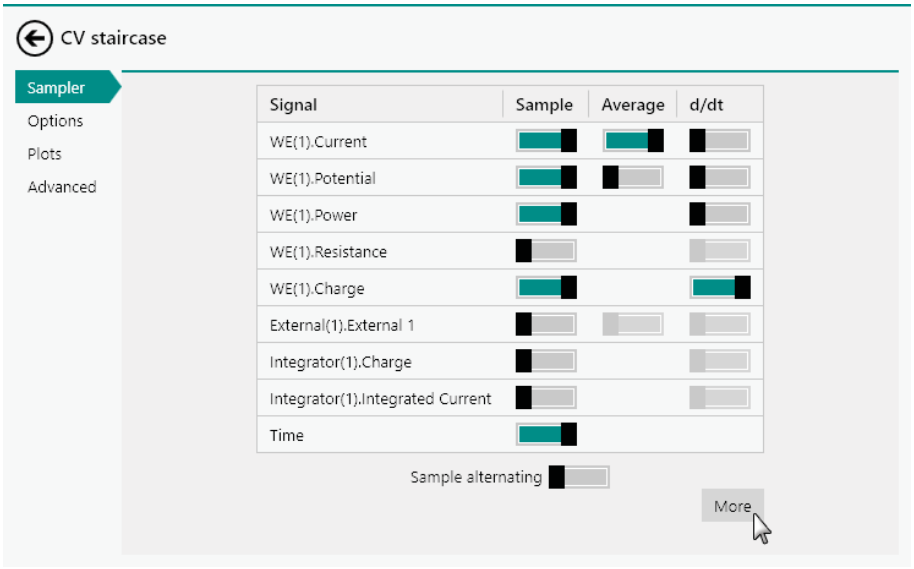


Figure 59 The Sampler editor now provides more information

Clicking the More button brings up a detailed table provide an overview of the sampling timing and duration *(see figure 60, page 64)*.

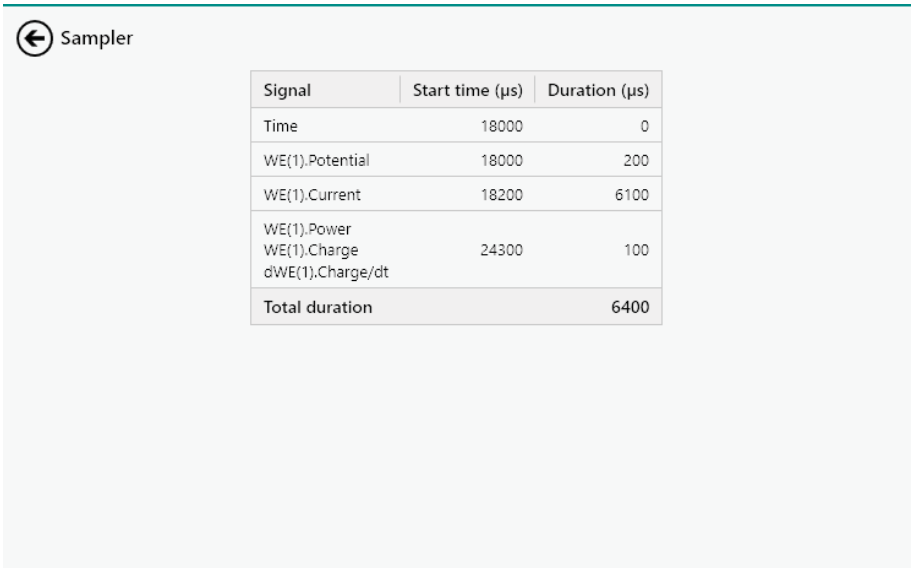


Figure 60 The sampling timing and duration is specified in the table

NOTICE

More information on the **Sampler** can be found in *Sampler (see chapter 9.1, page 616)*.

3.6.6 Zoom function for data analysis commands

The **Baseline correction** and **Electrochemical circle fit** analysis commands have been complemented with a zoom function that can be used to fine tune the location of the markers used by these commands *(see figure 61, page 65)*.

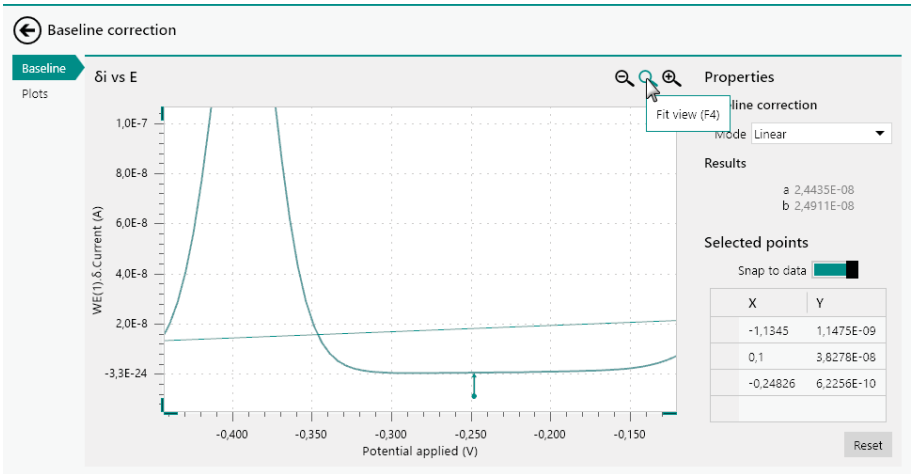


Figure 61 Zooming in and out is now possible for relevant analysis commands

NOTICE

More information on this new option can be found in *Chapter 12.7.1* and in *Chapter 12.9.1* for the **Baseline correction** and **Electrochemical circle fit** commands, respectively.

3.6.7 Custom name for Build signal command

It is now possible to define a custom name to the signals generated by the **Build signal** command, as shown in *Figure 62*.

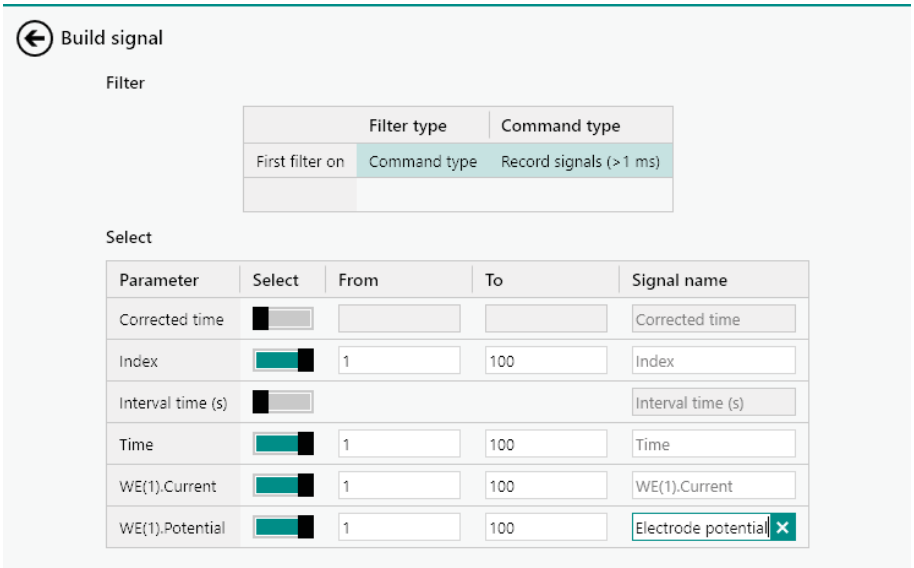


Figure 62 The Build signal command now offers the possibility to provide custom names

By default, the signal name will be the same of the signal selected by the **Build signal** command. This can be overruled by specifying a custom name.

NOTICE

More information on the **Build signal** command can be found in *Chapter 7.7.2*.

3.7 Version 2.0.1 release

Version 2.0.1 adds the following functionality:

1. Tagging of procedure and data files *Procedure and data tags (see chapter 3.7.1, page 67)*.
2. New plot options *New plot options (see chapter 3.7.2, page 68)*.
3. A new mechanism for importing data from GPES and FRA into NOVA *Import data (see chapter 3.7.3, page 70)*.
4. The number of recent items shown in the **Recent items** panel can now be edited *Number of recent items (see chapter 3.7.4, page 70)*.
5. Data files in the **Library** can now be expanded with a preview plot *Plot preview (see chapter 3.7.5, page 71)*.
6. Print functionality for plots *Print plot (see chapter 3.7.6, page 72)*.
7. NOVA is now completely region insensitive *Region insensitivity (see chapter 3.7.7, page 74)*.
8. A new mechanism for quickly switching the active electrochemical interface between the PGSTAT and the ECI10M *Electrochemical interface toggle (see chapter 3.7.8, page 74)*.
9. A dedicated indicator is now used for measurements using the ECI10M module *ECI10M measurements (see chapter 3.7.9, page 75)*.
10. The display settings used in the Library are now non-volatile *Library column display (see chapter 3.7.10, page 77)*.
11. The display settings used in data grids are now non-volatile *Data grid column display (see chapter 3.7.11, page 77)*.
12. The Estimated duration value is now shown in the **Properties** panel *Estimated duration (see chapter 3.7.12, page 78)*.
13. An **Interpolate** command is now available in the Analysis - general group of commands *Interpolate command (see chapter 3.7.13, page 79)*.
14. The **Hydrodynamic analysis** command has been extended with the Koutecký-Levich analysis technique *Hydrodynamic analysis (see chapter 3.7.14, page 79)*.

3.7.1 Procedure and data tags

It is now possible to assign tags to procedures and data files. This is a convenient tool for bookkeeping purposes. The controls for tagging data or procedures are provided in **Tags** sub-panel of the **Properties** panel of the procedure editor *(see figure 63, page 67)*.

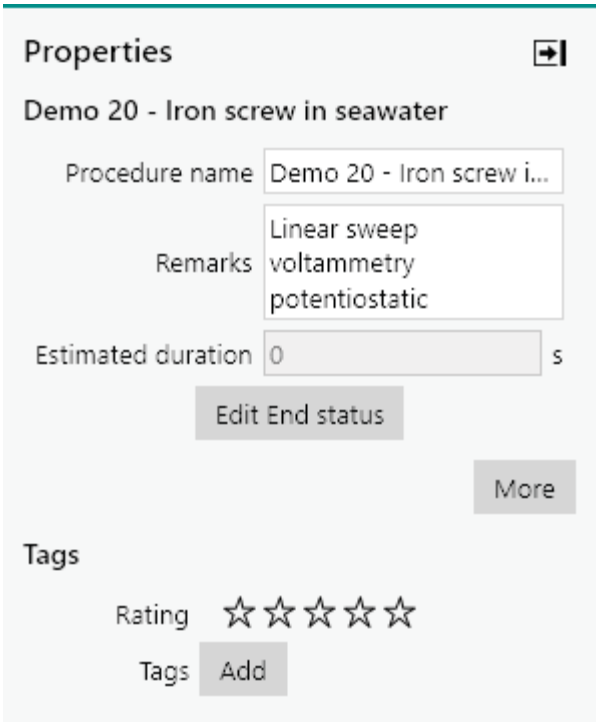


Figure 63 The Tags sub-panel provides controls for tagging data and procedure files

Two types of tags can be assigned to data or procedures:

- **Rating:** a rating based on a stars system can be assigned to each data or procedure file. By default, no stars are assigned to a file, but it is possible to change this at any time.
- **Tags:** text tags can be added to each data or procedure file. By default, no tags are assigned to a file, but it is possible to change this at any time.

NOTICE

The rating and tags are updated when the file is saved.

It is also possible to provide a rating and tags directly from the Library *(see figure 64, page 68)*.

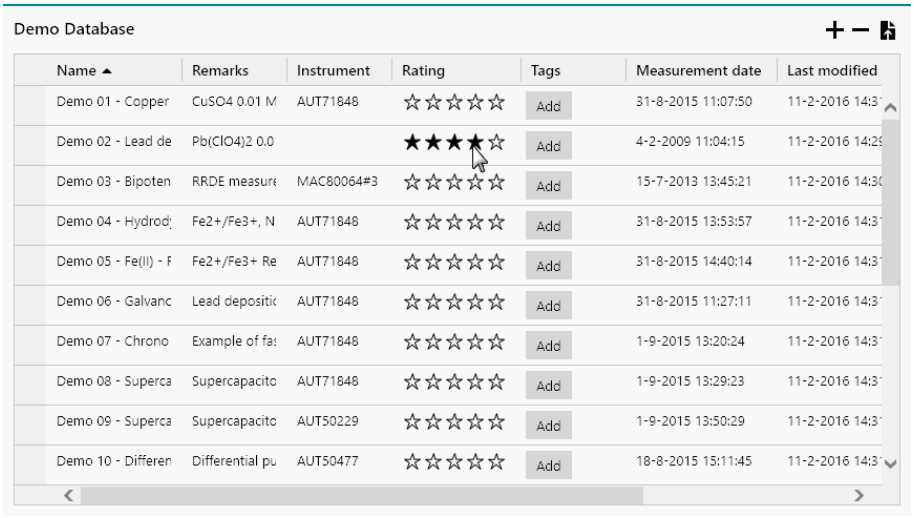


Figure 64 Tags can also be defined in the Library

NOTICE

More information on the rating and tagging of procedures and data can be found in *Chapter 6.8*.

3.7.2 New plot options

The plot options have been expanded in order to allow for additional control of the plotting of data *(see figure 65, page 69)*.

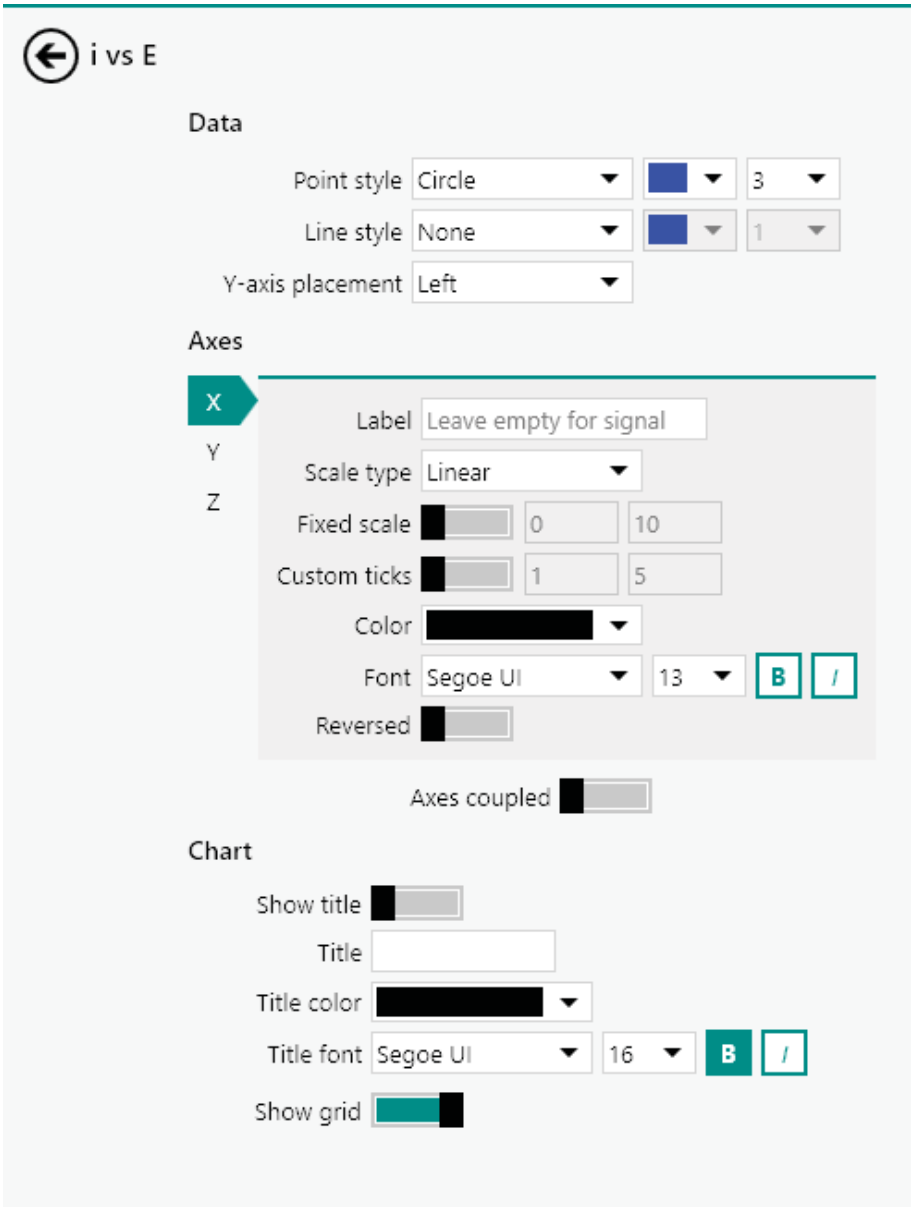


Figure 65 New plot options have been added to the Axes sub-panel

The following options have been added to the **Axes** sub-panel:

- **Fixed scale (on/off):** defines if the axis should be automatically scaled or if a fixed scale should be used. When this property is switched on, it is possible to define a minimum and maximum value for the axis.
- **Custom ticks (on/off):** defines if custom major and minor ticks should be used for the axis. When this property is switched on, it is possible to define the distribution of major and minor ticks.

3.7.3 Import data

It is now possible to import data from the **GPES** and **FRA** software into NOVA using the Import data button in the **Actions** panel. When this button is clicked, the file type can be selected in the Open file dialog window *(see figure 66, page 70)*.

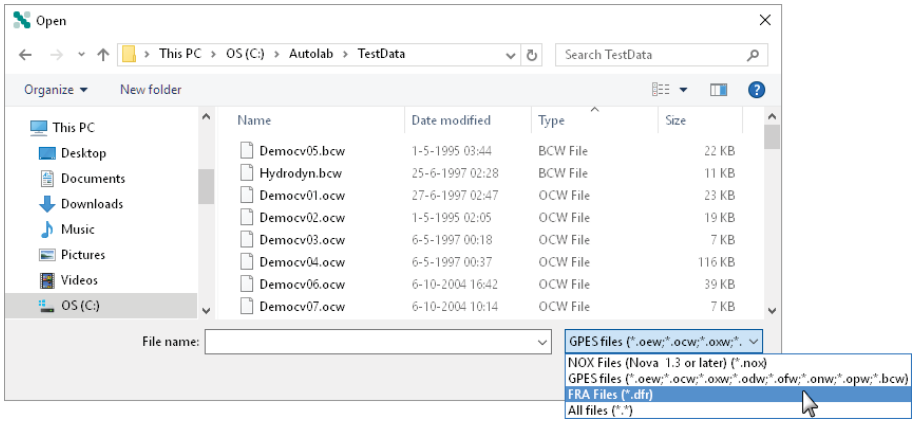


Figure 66 The file type can be specified in the Open file dialog window

The specified GPES or FRA data file will be imported directly into the Library.

This new functionality carries out the following steps after the file is selected by the user:

1. A new procedure is created.
2. The name of the new procedure is changed to the name of the file specified by the user.
3. An **Import data** command is added to the new procedure.
4. The specified file and path are used for the **Import data** command.
5. The procedure is automatically executed and the data is saved.

NOTICE

The new Import data functionality works in the same way as the existing functionality provided by the **Import data** command *Import data (see chapter 7.7.5, page 358)*.

3.7.4 Number of recent items

The number of recent items can now be edited in the NOVA options *(see figure 67, page 71)*.

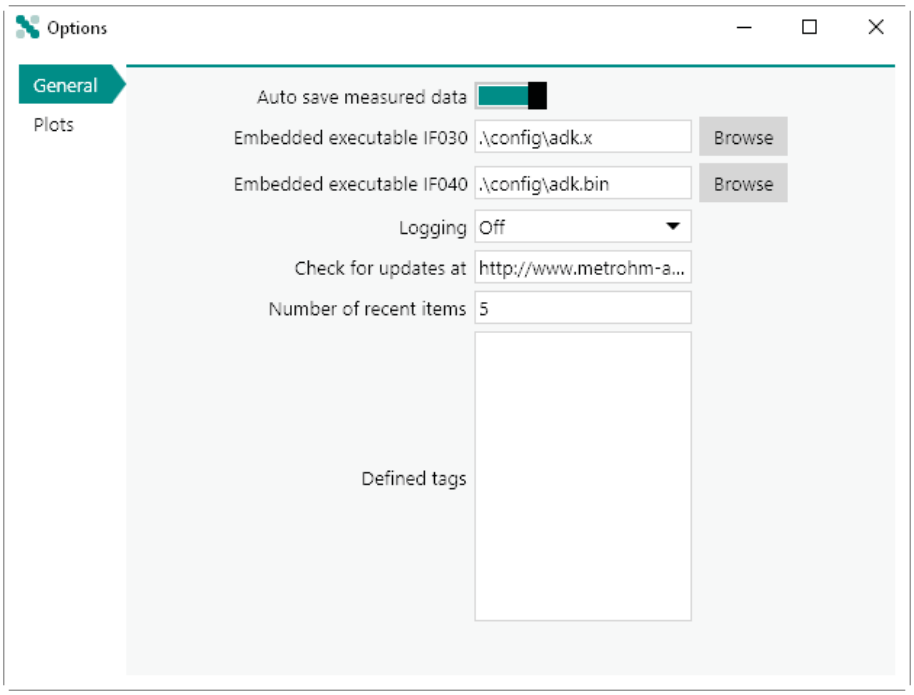


Figure 67 The number of recent items can be edited in the NOVA options

The default number of items is 5 and can be edited at any time.

3.7.5 Plot preview

NOVA now offers the possibility to assign one of the plots of a data file as a preview plot to display in the Library. This provides a quick preview of the data contained in each data file. The preview plot is shown in a tooltip *(see figure 68, page 72)*.

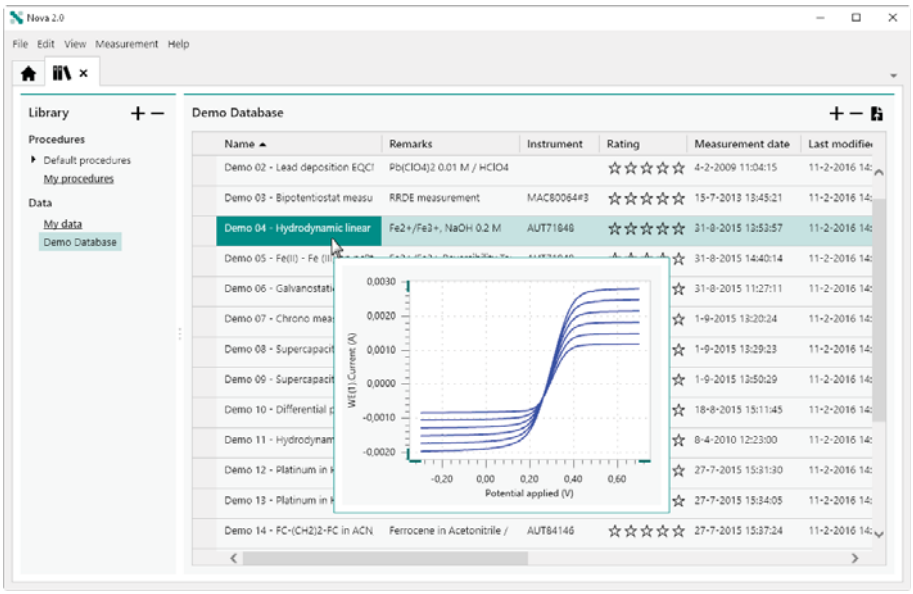


Figure 68 A plot preview is now added to each data item in the Library

NOTICE

Data measured with previous versions of NOVA will create a preview plot when changes to the file are saved in the current version.

NOTICE

More information on the plot previews can be found in *Chapter 6.9*.

3.7.6 Print plot

It is now possible to print plots using the provided button *(see figure 69, page 73)*.

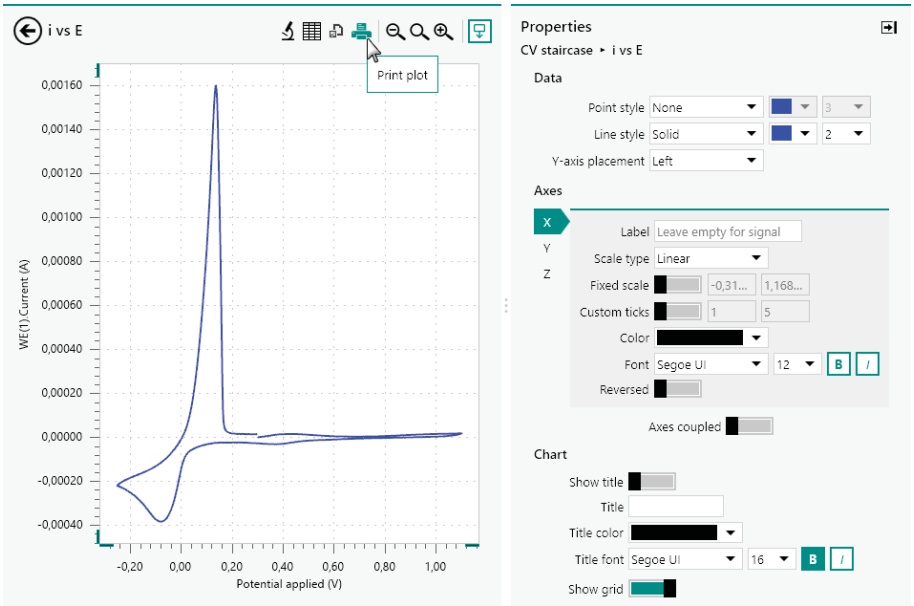


Figure 69 Plots can now be printed

A print preview dialog will be displayed, allowing finetuning of the print output *(see figure 70, page 73)*.

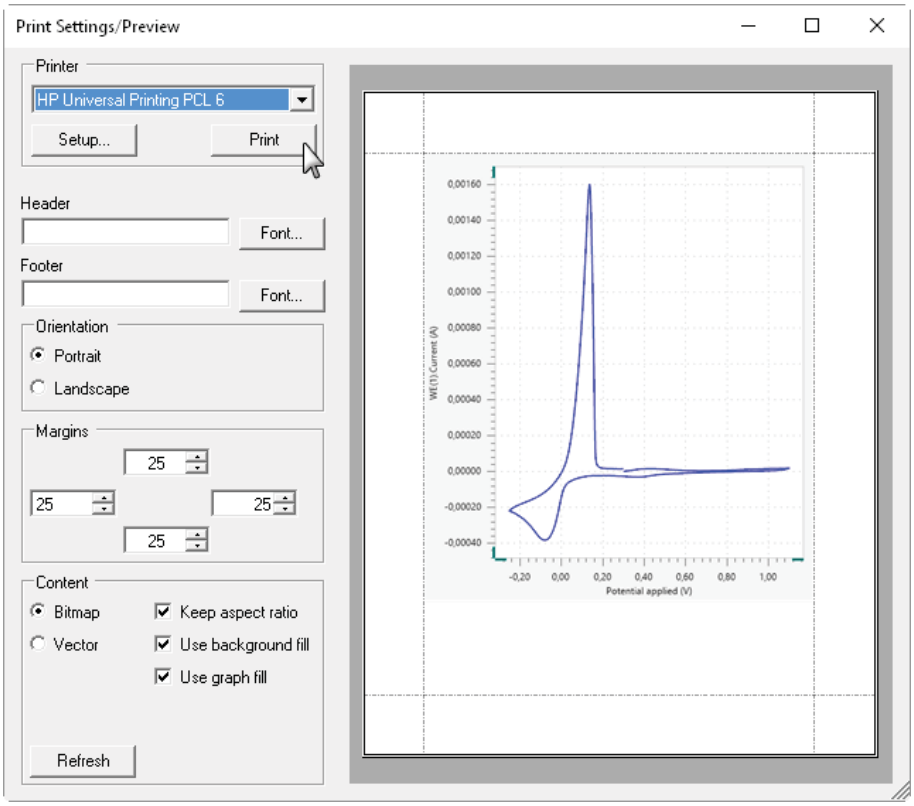


Figure 70 A print preview dialog is shown

NOTICE

More information on the printing of plots can be found in *Chapter 11.8.6*.

3.7.7 Region insensitivity

This version of NOVA is completely region independent. The application uses the regional settings defined on the computer. The Calculate signal command has been modified for this purpose. Mathematical operators that use more than one argument now use the semi-colon (**;**) to separate the arguments in the mathematical expression.

3.7.8 Electrochemical interface toggle

For instruments fitted with the optional **ECI10M** module it is now possible to set the active electrochemical interface directly from **Instruments** panel in the **Dashboard**, using the right-click menu *(see figure 71, page 74)*.

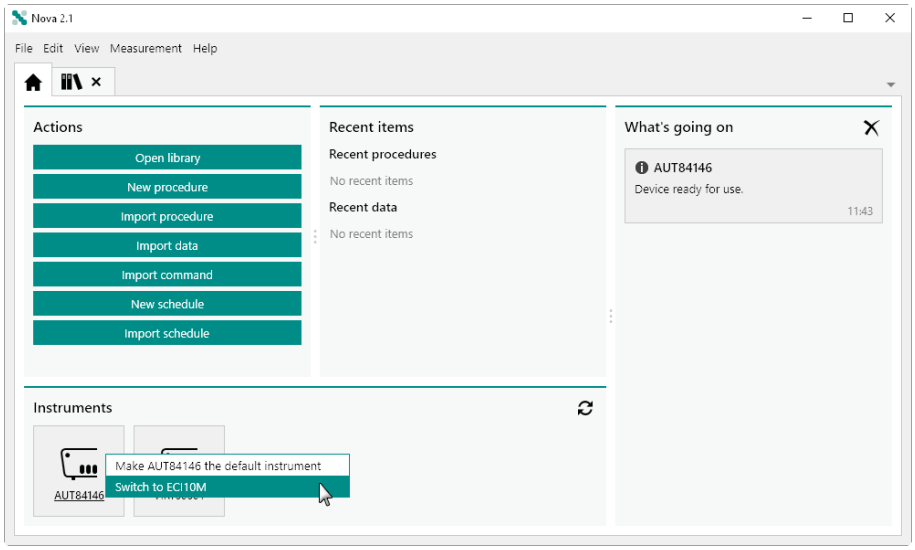


Figure 71 The electrochemical interface can be directly selected through the Dashboard

At any time, a tooltip shows the active electrochemical interface, in bold *(see figure 72, page 75)*.

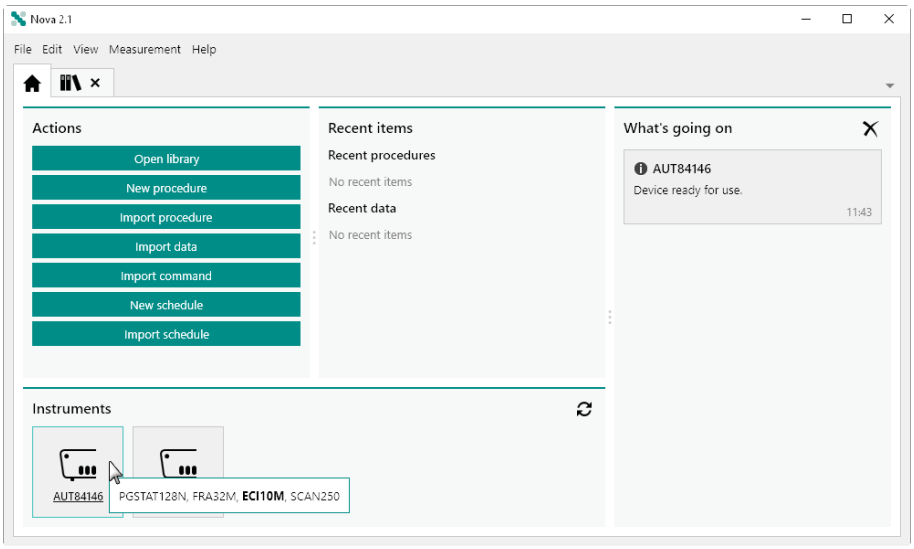


Figure 72 A tooltip shows the active electrochemical interface in bold

NOTICE

More information on the optional ECI10M module can be found in *Chapter 16.3.2.8*.

3.7.9 ECI10M measurements

In order to more easily identify measurements carried out with the **ECI10M** as the active electrochemical interface, the **(ECI10M)** suffix will be shown in the procedure editor, next to the serial number of the active instrument, below the procedure title *(see figure 73, page 76)*.

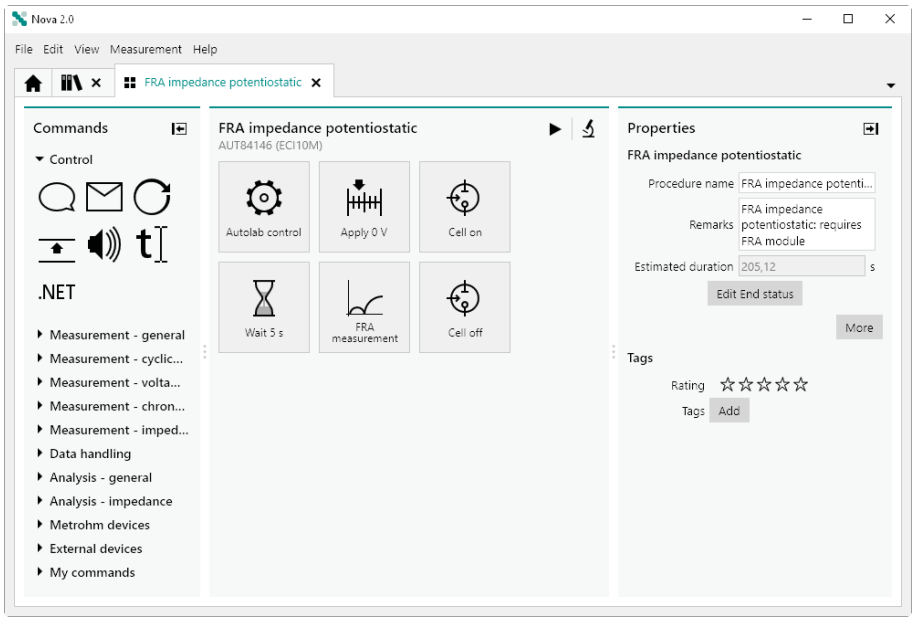


Figure 73 The ECI10M suffix is shown in the procedure editor

For measurements that have been carried out with the **ECI10M**, the same suffix will be added to the instrument serial number in the **Library***(see figure 74, page 76)*.

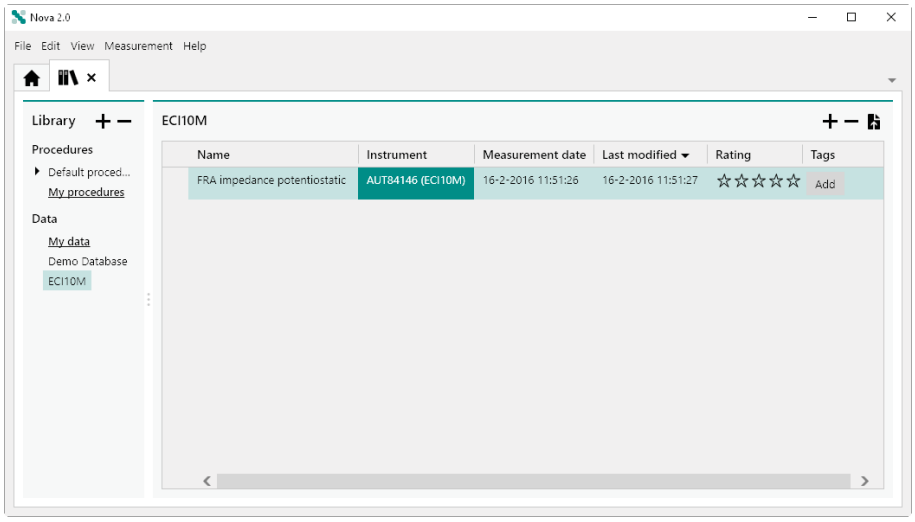


Figure 74 The ECI10M suffix is shown in the Library

NOTICE

This suffix is not shown for measurements carried out with previous version of NOVA.

3.7.10 Library column display

The display settings of the grids used in the **Library** are now non-volatile. This change affects the following settings of the Library:

- **Column order:** the order in which the columns appear.
- **Column visibility:** the visibility of the available columns.
- **Sorting options:** the sorting options used in the Library.

NOTICE

The display settings used in the Library are stored on the local computer and can be defined for each type of Library location.

NOTICE

More information on the display settings used in the Library can be found in *Chapter 6.10* and *Chapter 6.13*.

3.7.11 Data grid column display

The display settings of the grids used in the **Data grid** are now non-volatile. This change affects the following settings of the data grid:

- **Column order:** the order in which the columns appear.
- **Column formatting:** the data formatting used in each column.
- **Sorting options:** the sorting options used in the data grid.

NOTICE

These settings are stored for each command in the data file.

NOTICE

More information on the display settings used by the data grid can be found in *Chapter 11.9*.

3.7.12 Estimated duration

The **Estimated duration** is now shown as read only field for all commands in the **Properties** panel *(see figure 75, page 78)*.

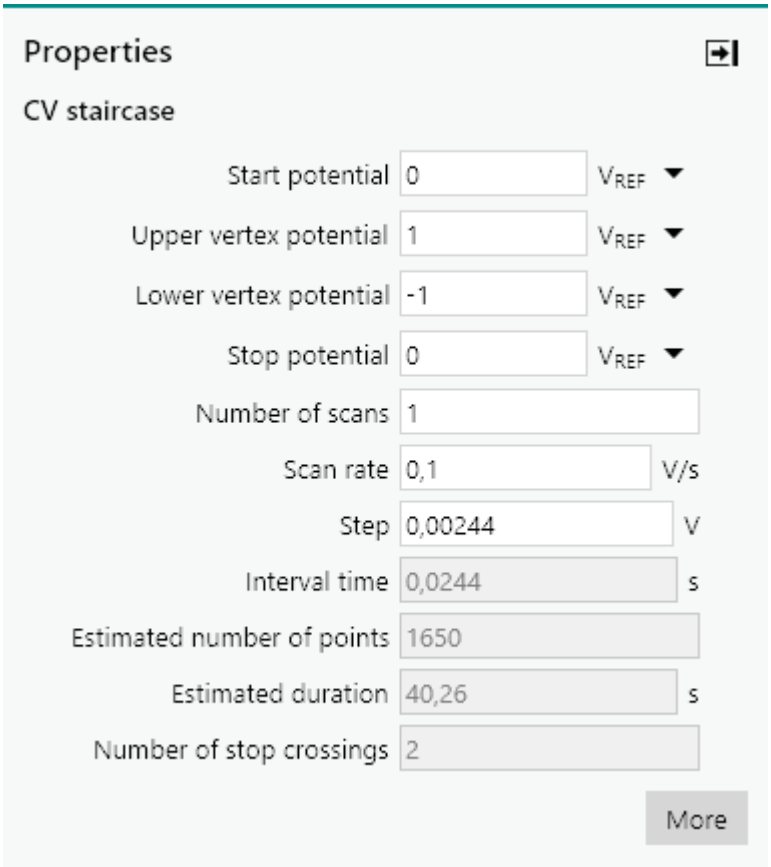


Figure 75 The Estimated duration is now specified in the Properties panel

If the command is part of a command stack, the Estimated duration value will take into account the duration of the all the underlying commands in the stack, as shown in *Figure 76*.

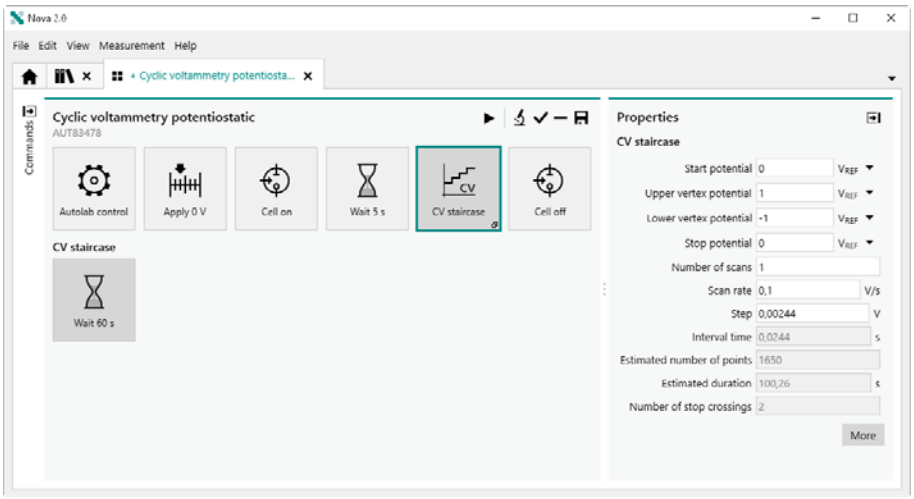


Figure 76 When commands are stacked, the Estimated duration takes underlying commands into account

NOTICE

The Estimated duration is determined based on the interval time and the estimated number of points as well as the duration of underlying commands, if applicable.

3.7.13 Interpolate command

The new Interpolate command, available in the Analysis - general group of commands, is now available. This command can be used to determine Y or X value based on a user-defined X or Y value, by linear interpolation.

NOTICE

More information on the Interpolate command can be found in *Chapter 7.8.6*.

3.7.14 Hydrodynamic analysis

The Hydrodynamic i vs $\sqrt{\omega}$ command has been renamed to **Hydrodynamic analysis** and it has been extended with the Koutecký-Levich analysis method .

NOTICE

More information on the **Hydrodynamic analysis** command can be found *Hydrodynamic analysis (see chapter 7.8.10, page 386)*.

3.8 Version 2.0 release

NOVA 2.0 is completely redesigned to improve the user experience. The tree view from the previous generation of NOVA (NOVA 1.2 to NOVA 1.11) has been replaced by a graphical interface with a clear presentation. This manual explains all the controls of NOVA 2.0.

The following new functionality has been added to the software with respect to the previous versions of NOVA:

1. Dynamic data buffers *Dynamic data buffers (see chapter 3.8.1, page 80)*.
2. Value of alpha for staircase cyclic voltammetry and staircase linear sweep voltammetry *Value of Alpha (see chapter 3.8.2, page 81)*.
3. Support for the Autolab RHD Microcell HC system *Autolab RHD Microcell HC support (see chapter 3.8.3, page 81)*.
4. PGSTAT204 and M204 compatibility with the Booster10A *PGSTAT204 and M204 combination with Booster10A support (see chapter 3.8.4, page 82)*.
5. Support for the ECI10M module *ECI10M module support (see chapter 3.8.5, page 82)*.
6. AC voltammetry procedure and command *AC voltammetry (see chapter 3.8.6, page 83)*.

3.8.1 Dynamic data buffers

NOVA 2.0 introduces **dynamic data buffers**, a data storage mechanism that allows data points to be stored during a measurement. This means that the measurement commands are no longer affected by static buffers and that they can record as many data points as needed. The actual limit of to the number of data points is therefore only limited to the storage space available on the computer.

NOTICE

Dynamic buffers are not available for measurements carried out with the **Chrono methods** command and for all measurements carried out with the **ADC10M** module or the **ADC750** module.

3.8.2 Value of Alpha

For the **CV staircase** command and the **LSV staircase** command, the *Alpha value* advanced property is now available *(see figure 77, page 81)*.

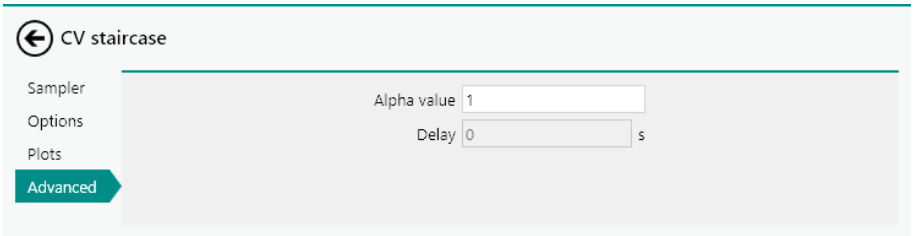


Figure 77 The Alpha value property is available for the CV staircase and LSV staircase command

NOTICE

More information on the use of the value of Alpha can be found in *Chapter 9.7*.

3.8.3 Autolab RHD Microcell HC support

NOVA 2.0 introduces support for the Autolab RHD Microcell HC support *(see figure 78, page 81)*.

Figure 78 The Autolab RHD Microcell system

NOTICE

More information on the Autolab RHD Microcell HC is provided in *Chapter 5.3* and *Chapter 7.11.3*.

3.8.4 PGSTAT204 and M204 combination with Booster10A support

NOVA 2.0 introduces support for the combination of the Autolab PGSTAT204 potentiostat/galvanostat and the M204 potentiostat/galvanostat module with the Booster10A *(see figure 79, page 82)*.

Figure 79 The combination of the Booster10A with the PGSTAT204/M204 system is now supported

NOTICE

More information on the combination of the Booster10A with the PGSTAT204 and the M204 can be found in *Chapter 16.3.2.5*.

3.8.5 ECI10M module support

NOVA 2.0 introduces support for the ECI10M module *(see figure 80, page 83)*.

Figure 80 NOVA introduces the support of the ECI10M module

NOTICE

More information on the ECI10M module can be found in *Chapter 16.3.2.8*.

3.8.6 AC voltammetry

This new version of NOVA provides a new command for AC voltammetry measurements *AC voltammetry (see chapter 7.4.7, page 283)*. A default procedure for this electrochemical method is also available *AC voltammetry (see chapter 8.3.6, page 551)*.

4 Dashboard

The **Dashboard** is the home screen of NOVA. Whenever NOVA starts, the **Dashboard** is always shown to the user *(see figure 81, page 84)*.

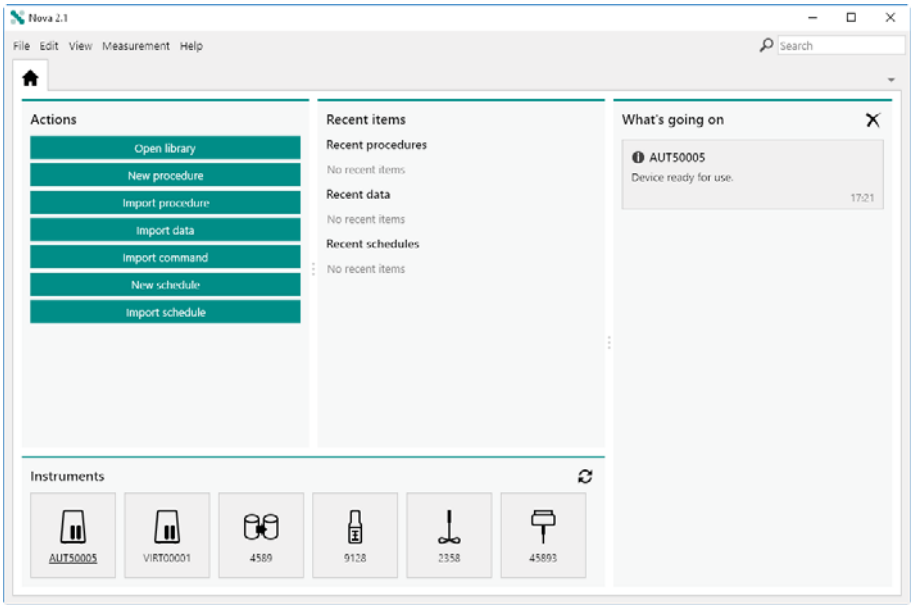


Figure 81 The Dashboard

At any time, when NOVA is used, it is possible to show the display by clicking the home tab (🏠). The Dashboard provides four different panels:

- **Actions:** this panel provides a list a shortcut buttons to trigger a common task in NOVA *Actions (see chapter 4.1, page 85)*.
- **Recent items:** this panel provides a list of the last procedures, data and schedule items *Recent items (see chapter 4.2, page 86)*.
- **What's going on:** this panel provides messages to the user about ongoing or finished events in NOVA *What's going on (see chapter 4.3, page 88)*.
- **Instruments:** this panel provides a list of connected instruments *Instruments panel (see chapter 4.4, page 90)*.

4.1 Actions

The **Actions** panel provides a series of buttons that can be used to quickly trigger a common action or control of the NOVA software *(see figure 82, page 85)*.

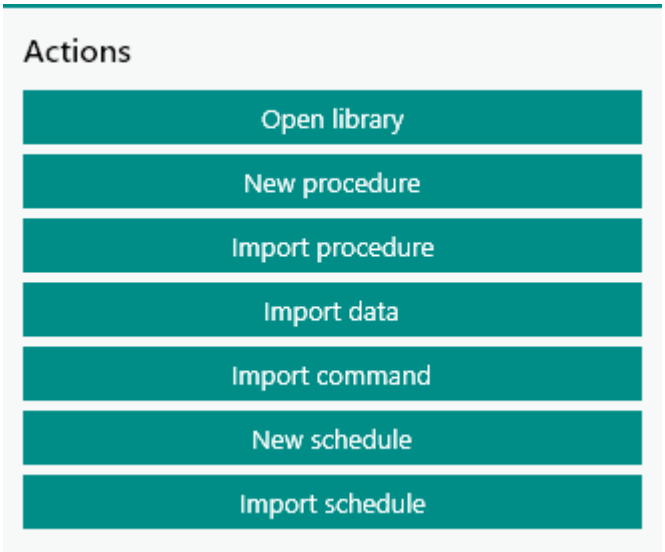


Figure 82 The Actions panel provides shortcut to the most common actions in NOVA

The following shortcut buttons are provided:

- **Open library:** this button open the **Library**. More information on the **Library** can be found in *Chapter 6*.
- **New procedure:** creates a new blank procedure. More information on the procedure editor can be found in *Chapter 10.1*.
- **Import procedure:** imports a procedure from a *.nox* file in the **Library**. More information on the **Library** can be found in *Chapter 6*.
- **Import data:** imports NOVA data from a *.nox* file in the **Library**. More information on the **Library** can be found in *Chapter 6*.
- **Import command:** imports a command from a *.noi* file in the **My Commands** group of command. More information on the **My Commands** can be found in *Chapter 10.14*.
- **New schedule:** creates a new procedure schedule. More information on the **Procedure scheduler** can be found in *Chapter 15*.
- **Import schedule:** imports a procedure schedule from a *.nos* file in the **Library**. More information on the **Procedure scheduler** can be found in *Chapter 15*.

NOTICE

The **Import data** action can also be used to directly import data from the **GPES** and **FRA** software into NOVA.

4.2 Recent items

The **Recent items** panel lists the most recent procedures, data and schedules items *(see figure 83, page 86)*.

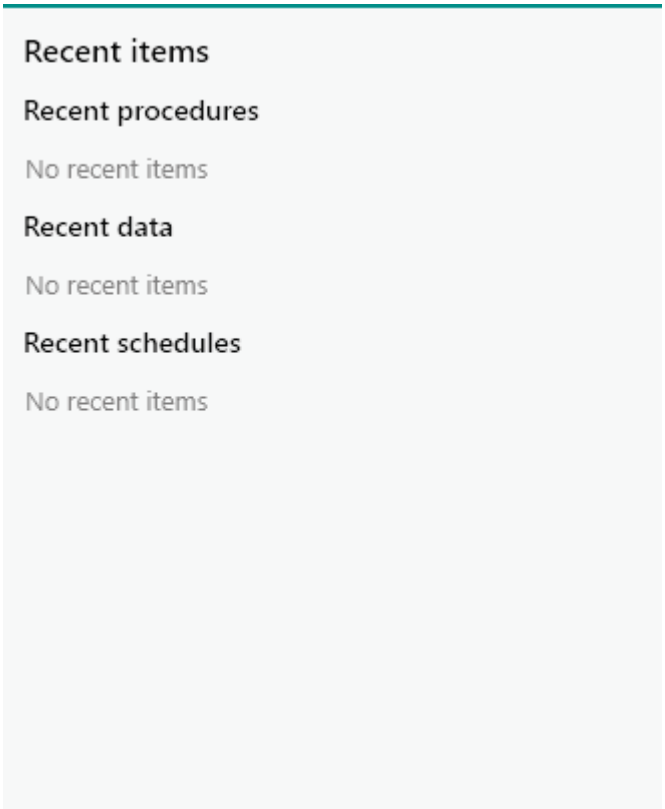


Figure 83 The Recent items panel shows the last procedures, data and schedules items

NOTICE

By default, the **five** most recent items are shown in the **Recent items** panel. This number can be adjusted in the NOVA Options *Options (see chapter 1.9, page 13)*.

The last items that are saved are automatically updated in the **Recent items** panel each time an item is saved *(see figure 84, page 87)*.

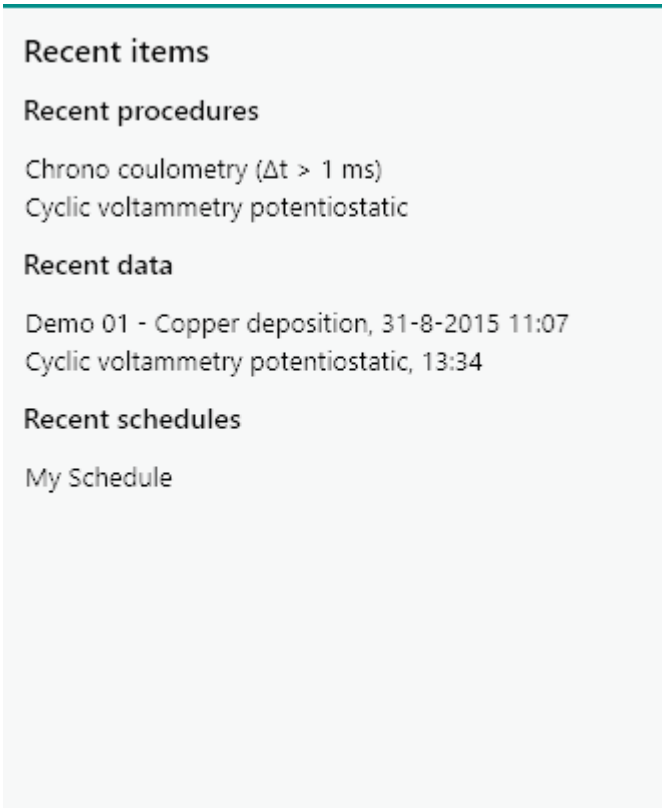


Figure 84 The Recent items panel is automatically updated when data or procedures are saved

It is possible to remove items from the **Recent items** panel by right-clicking an item and selecting the *Remove from recent items* option from the context menu *(see figure 85, page 88)*.

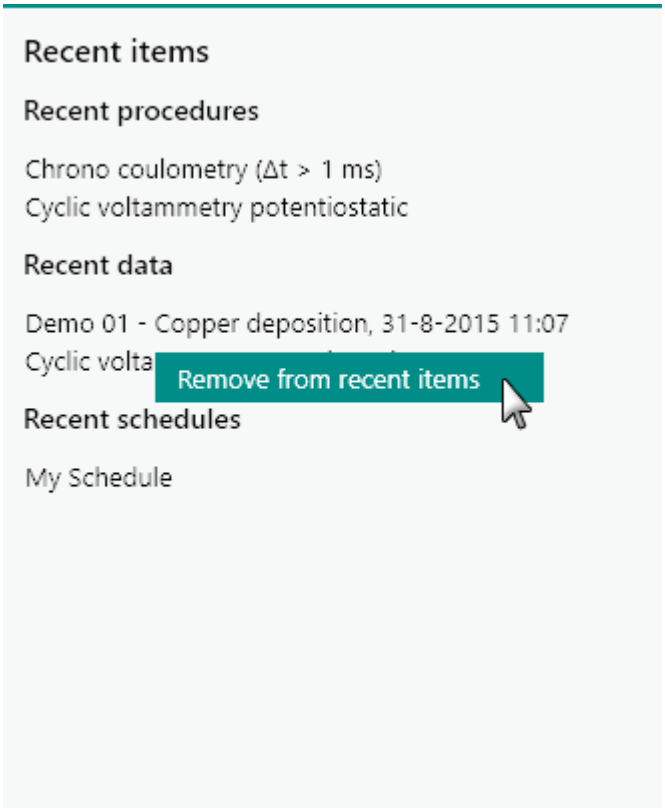


Figure 85 Removing items from the Recent items panel

4.3 What's going on

The **What's going on** panel is used to report information to the user. On startup, this panel will be populated with messages indicating that the connected Autolab instruments are ready for use *(see figure 86, page 89)*.

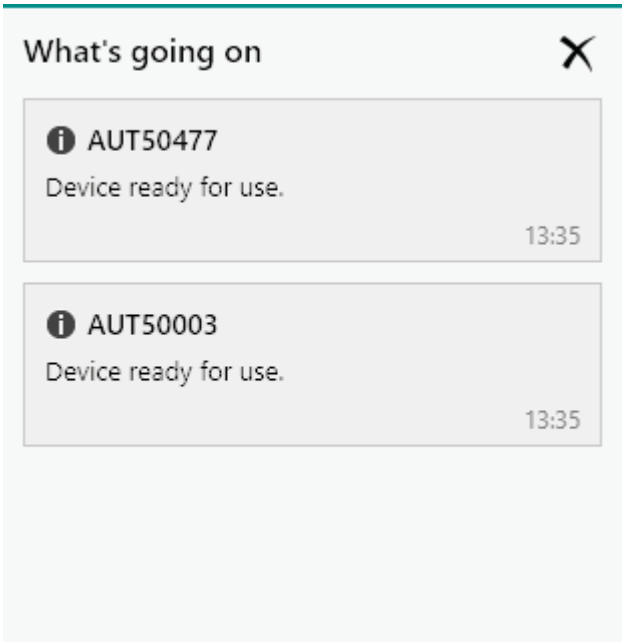


Figure 86 The What's going on panel is used to provide messages to the user

At any time, it is possible to clear the **What's going on** panel using the ✕ button *(see figure 87, page 89)*.

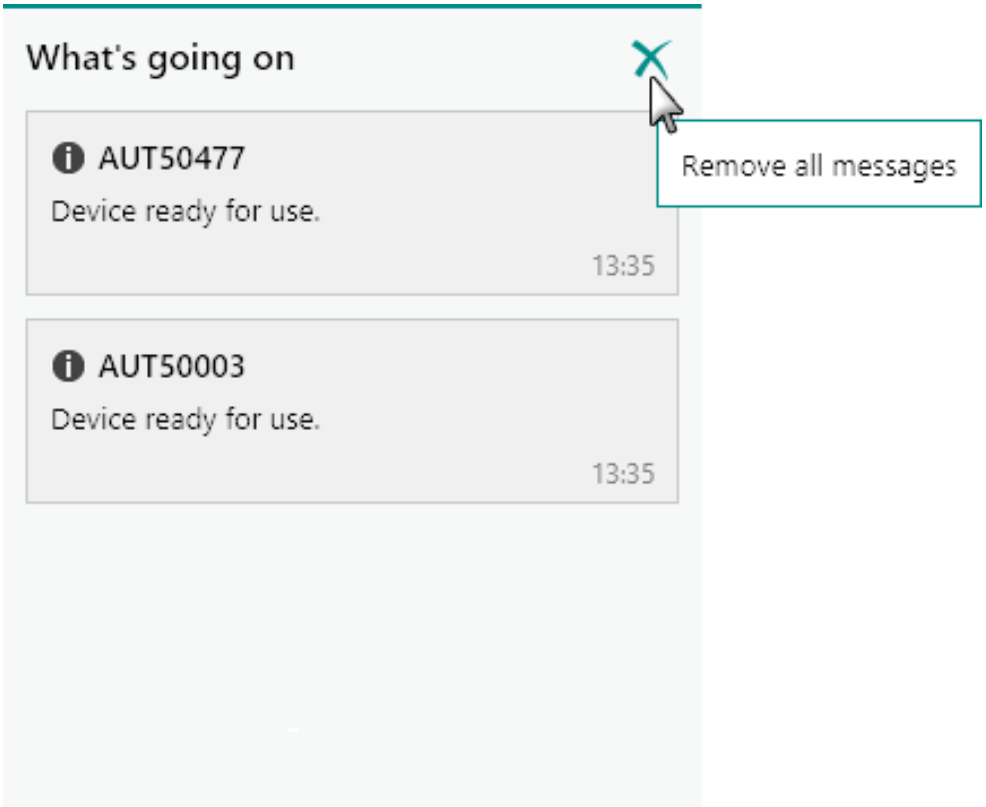


Figure 87 Clearing the panel content

The panel will be cleared of the currently displayed message.

Any time a measurement is started or a measurement stops, the **What's going on** panel will be updated *(see figure 88, page 90)*.

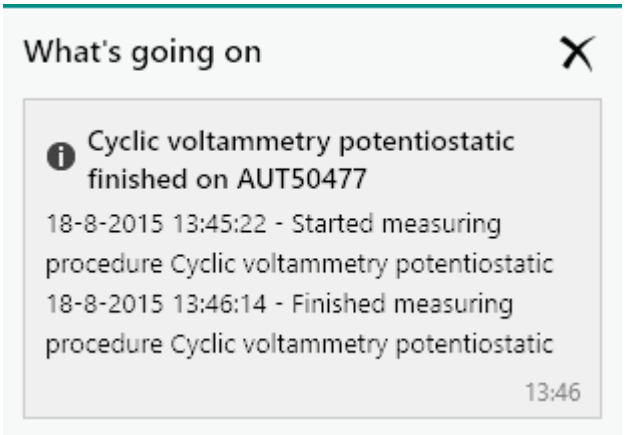


Figure 88 The What's going on panel is updated each time a measurement is started or finishes

4.4 Instruments panel

The **Instruments** panel shows all the connected instruments identified by NOVA *(see figure 89, page 90)*.

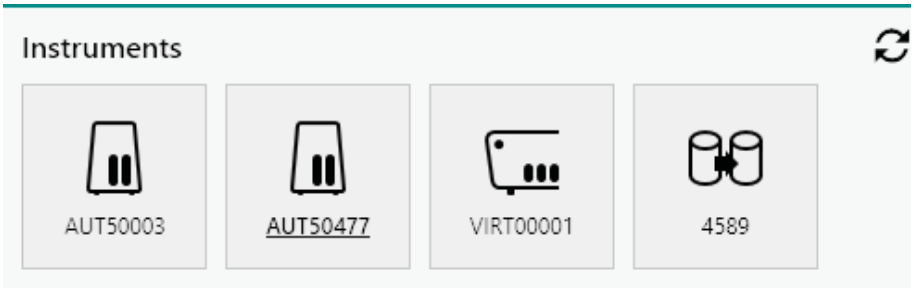


Figure 89 The Instruments panel lists all connected instruments

On startup, NOVA will look for all supported devices and will list these in **Instruments** panel. The content of the panel is automatically refreshed whenever an Autolab potentiostat/galvanostat, Autolab RHD Microcell HC controller of Autolab Spectrophotometer is connected or disconnected from the computer. The panel content is **not** refreshed automatically when a Metrohm liquid handling device is connected or disconnected. To refresh the content of the **Instruments** panel and update the list of available instruments, it is possible to click the button *(see figure 90, page 91)*.

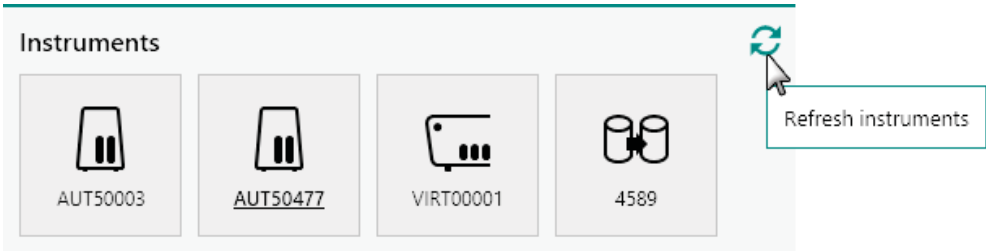


Figure 90 Clicking the refresh button will update the content of the Instruments panel

The content of the Instrument panel is updated when the button is clicked *(see figure 91, page 91)*.

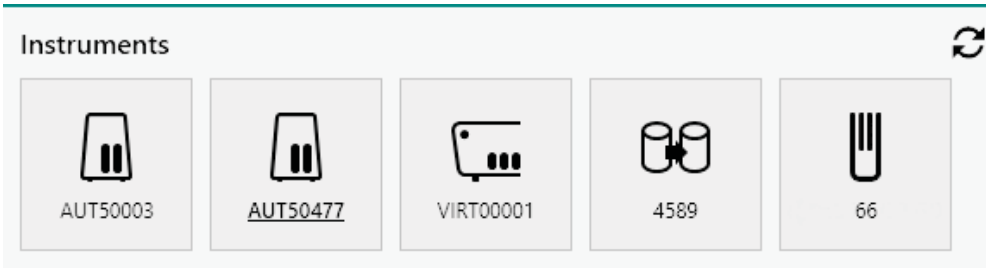


Figure 91 The Instruments panel is refreshed

5 Instruments panel

All connected instruments are listed in the **Instruments** panel of the dashboard *(see figure 92, page 92)*.

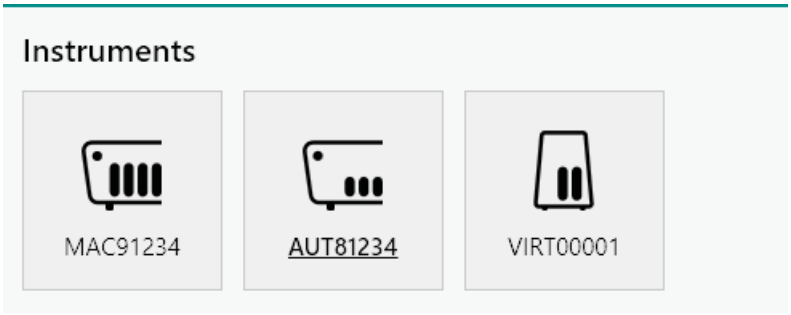


Figure 92 Connected instruments are listed in the Instruments panel

The following instruments can be identified by NOVA:

- Autolab potentiostat/galvanostat instruments with USB interface
- Autolab RHD Microcell HC controllers
- Autolab or Avantes spectrophotometers
- Supported Metrohm liquid handling devices

The instruments are identified by type and by serial number, and are represented by a device tile with a drawing of the instrument. Alongside the connected instrument, a **virtual** instrument is also shown.

NOTICE

The virtual instrument is provided for procedure validation purposes.

The following device tiles are used to identify the connected **Autolab** instruments:

	This symbol is used to identify all **Autolab N Series** instruments (PGSTAT302N, PGSTAT128N, PGSTAT100N) or **Autolab F Series** instruments (PGSTAT302F). These instruments have a serial number starting with **AUT8**.

	This symbol is used to identify all **Autolab PGSTAT204** instruments. These instruments have a serial number starting with **AUT5**.
	This symbol is used to identify all **Autolab PGSTAT101** instruments. These instruments have a serial number starting with **AUT4**.
	This symbol is used to identify all **Multi Autolab Series** instruments (M101 and M204). These instruments have a serial number starting with **MAC8** (for the M101 Multi Autolab systems) and **MAC9** (for the M204 Multi Autolab systems).
	This symbol is used to identify all **µAutolab type II** and **µAutolab type III** instruments. The µAutolab type II instruments are identified by a serial number starting with **µ2AUT7** and the µAutolab type III instruments are identified by a serial number starting with **µ3AUT7**.
	This symbol is used to identify all **Autolab 7 Series** instruments (PGSTAT302, PGSTAT30, PGSTAT12, PGSTAT100) as well as the older **Autolab 9 Series** instruments (PGSTAT30, PGSTAT20, PGSTAT10 and PGSTAT100). These instruments are identified by a serial number starting with **AUT7** or **USB7**.

The following tiles are used to identify the connected **Autolab RHD Microcell HC** controllers:

	This symbol is used to identify all **Autolab RHD Microcell HC controllers** connected to the computer through a RS232 connection. These instruments are identified by their serial number (or device name).

The following tiles are used to identify the connected **Autolab or Avantes** spectrophotometers:

	This symbol is used to identify all **Autolab or Avantes spectrophotometers** connected to the computer through a USB connection. These instruments are identified by their serial number (or device name).

The following tiles are used to identify the connected **Metrohm** devices:

	This symbol is used to identify all **Metrohm 800 Dosino** devices connected to a USB controlled Metrohm device. These instruments are identified by their serial number (or device name).
	This symbol is used to identify all **Metrohm 801 Magnetic Stirrers** or **804 Titration Stands** with a stirrer connected to it (either **Metrohm 802 Rod Stirrer** or **Metrohm 741 Magnetic Stirrer**). These instruments are identified by their serial number (or device name).
	This symbol is used to identify all **Metrohm 814**, **815** or **858 Sample Processor** devices connected by USB to the host computer. These instruments are identified by their serial number (or device name).
	This symbol is used to identify all **Metrohm 6.2148.010 Remote Box** devices connected to a USB controlled Metrohm Device. These instruments are identified by their serial number (or device name).

In *Figure 92*, two instruments are connected (a Multi Autolab system with Serial Number MAC91234 and an Autolab N Series instrument with serial number AUT81234). A virtual instrument, with serial number VIRT00001 is also connected. This instrument is identified as a PGSTAT204.

The serial number of the N series instrument is shown in bold underlined font (**AUT81234**) indicating that this is the *default* instrument.

NOTICE

When a measurement is started, it will always be executed on the *default* instrument, unless otherwise specified.

The following actions can be performed in the **Instruments** panel:

- Change the *default* **Autolab** instrument.
- Open the instrument control panel.

5.1 Change the default instrument

The default instrument, displayed in the bold underline in the **Instruments** panel, is the instrument used in any measurement, unless otherwise specified. This is also the instrument used for procedure validation purposes.

To change the default instrument, right-click any instrument tile in the **Instruments** panel and select the *Make* **[Instrument serial number]** *the default instrument* from the context menu *(see figure 93, page 95)*.

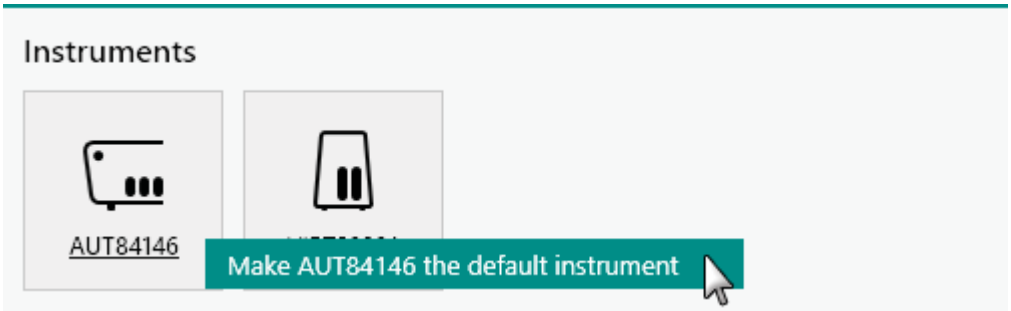


Figure 93 Defining the default instrument

NOTICE

Only one instrument can be set as default instrument.

5.2 Autolab control panel

Double clicking an Autolab tile in the **Instruments** panel opens the **Autolab control** panel in a new **tab**, as shown in *Figure 94* and *Figure 95*.

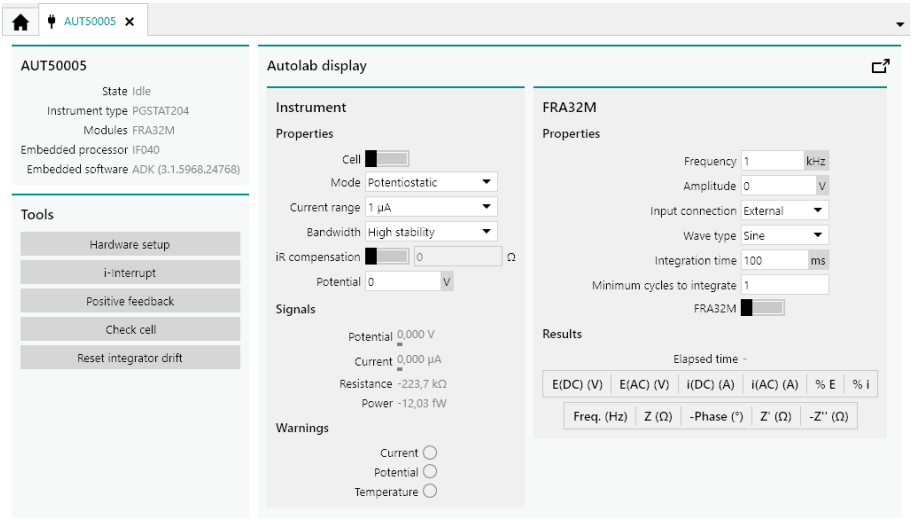


Figure 94 The single channel Autolab control panel

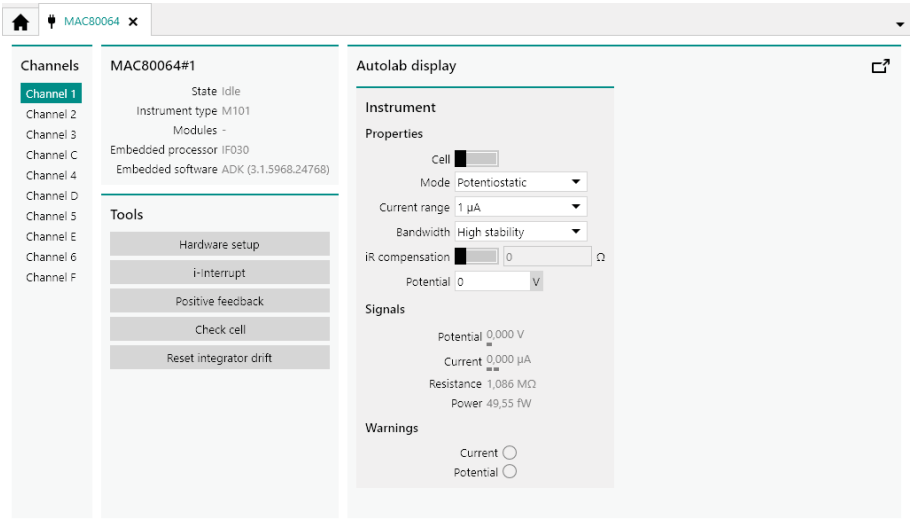


Figure 95 The multi channel Autolab control panel

Depending on the type of instrument, the Autolab control panel shows either three or four sub-panels:

- **Channels:** this panel displays the available channels located in the Multi Autolab instrument. The information of the highlighted channel is shown in the rest of the screen. This panel is only visible for Multi Autolab instruments.

- **Instrument information panel:** this panel displays information about the instrument.
- **Tools panel:** this panel provides quick access to the hardware setup and a number of direct measurement tools like current interrupt and positive feedback.
- **Autolab display panel:** this panel provides a number of manual controls of the instrument.

NOTICE

The available channels in a multi channel Autolab are listed in the **Channels** sub-panel. Each channel is identified by a letter or a number. More information is provided in *Chapter 16.2.5*.

5.2.1 Instrument information panel

The **Instrument information** panel shown in the instrument control panel provides information on the selected instrument *(see figure 96, page 97)*.

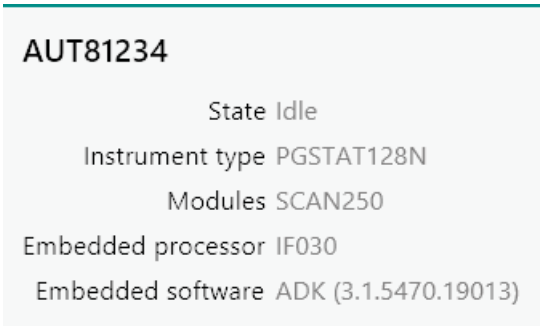


Figure 96 The Instrument information panel

This information is updated in real time and is provided for information only. The following items are listed:

- **State:** indicates the state of the instrument (idle or measuring).
- **Instrument type:** indicates the type of instrument.
- **Modules:** shows the extension modules of the instrument.
- **Embedded processor:** shows the type of embedded processor installed in the instrument (IF030 or IF040).
- **Embedded software:** shows the embedded application name and version number.

NOTICE

The embedded processor and embedded software reported in the instrument information panel are provided for information purposes only.

5.2.2 Tools panel

The **Tools** panel, shown in *Figure 97*, provides access to the following controls:

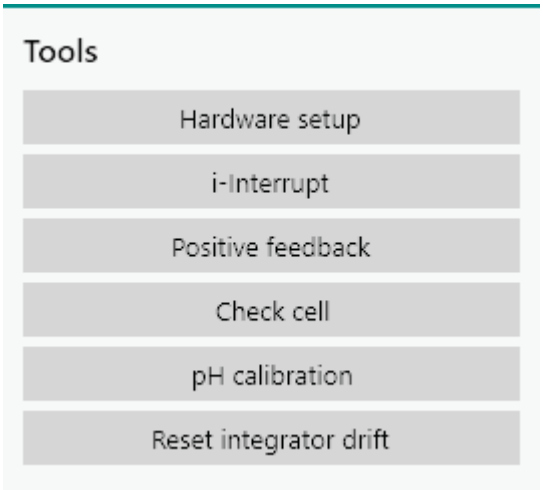


Figure 97 The Tools panel

- **Hardware setup:** used to adjust the hardware configuration of the instrument *Hardware setup (see chapter 5.2.2.1, page 99)*.
- **i-Interrupt:** performs a current interrupt measurement (i-Interrupt) on the connected electrochemical cell in order to determine the uncompensated resistance value, R_u, by regression *Current interrupt (see chapter 5.2.2.2, page 101)*.
- **Positive feedback:** performs a positive feedback measurement in order to determine the uncompensated resistance value, R_u, by inspecting the control loop stability on the connected electrochemical cell *Positive feedback (see chapter 5.2.2.3, page 107)*.
- **Check cell:** performs a noise test to evaluate the electrode connections *Check cell (see chapter 5.2.2.4, page 110)*.
- **pH calibration:** calibrates the pH sensor connected to the instrument *pH calibration (see chapter 5.2.2.5, page 114)*.
- **Reset integrator drift:** performs a determination of the drift, in C/s, of the analog integrator and resets the compensation of the drift to the appropriate value *Reset integrator drift (see chapter 5.2.2.6, page 126)*.

NOTICE

The i-Interrupt, Positive feedback, pH calibration and Reset integrator drift tools are only shown on if the instrument provides the functionality used by these tools.

5.2.2.1 Hardware setup

The Hardware setup button can be used to edit the **Hardware setup**. The hardware setup screen shows three panels *(see figure 98, page 99)*.

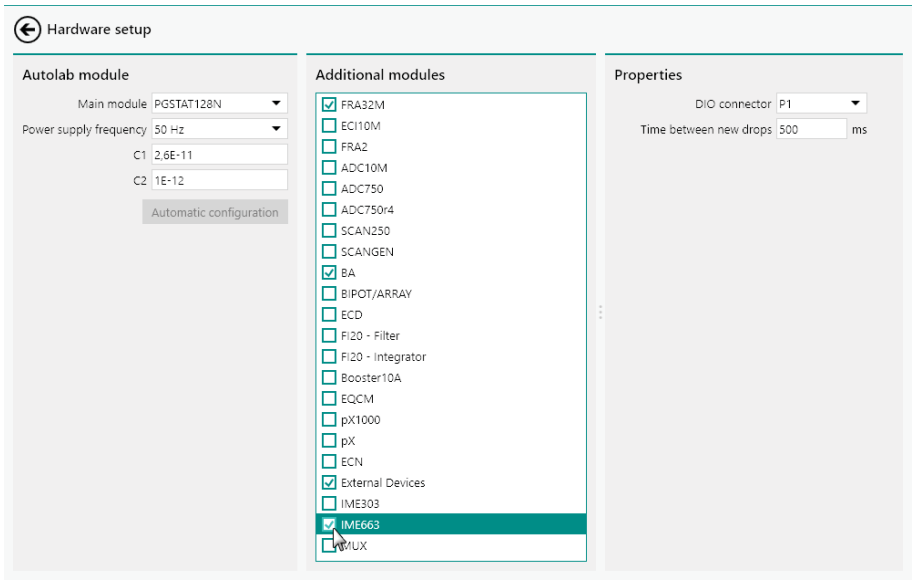


Figure 98 The hardware setup

The following panels are provided:

- **Autolab module panel:** used to specify the type of Autolab and additional properties of this instrument.
- **Additional modules panel:** provides a list of compatible extension modules which can be installed in the instrument or connected to the instrument.
- **Properties panel:** provides additional parameters for the extension modules.

5.2.2.1.1 Autolab module panel

The **Autolab module** panel can be used to specify the following properties *(see figure 99, page 100)*:

- **Main module:** specifies the type of Autolab using the provided drop-down list.
- **Power supply frequency:** specifies if the mains frequency is 50 or 60 Hz.

- **C1 and C2:** specifies the C1 and C2 correction parameters for electrochemical impedance measurements.

NOTICE

The values of **C1** and **C2** are preconfigured when NOVA is installed from the CD-ROM or USB support provided with the instrument. If these values are not configured properly (0 by default), the values can be determined experimentally. Please refer to *Chapter 16.3.2.13.3* and *Chapter 16.3.2.12.4* for more information.

Furthermore, an additional Automatic configuration button is provided. Clicking this button automatically adjusts the hardware setup of the instrument. The main module and the optional modules are determined based on the information stored on the instrument *(see figure 99, page 100)*.

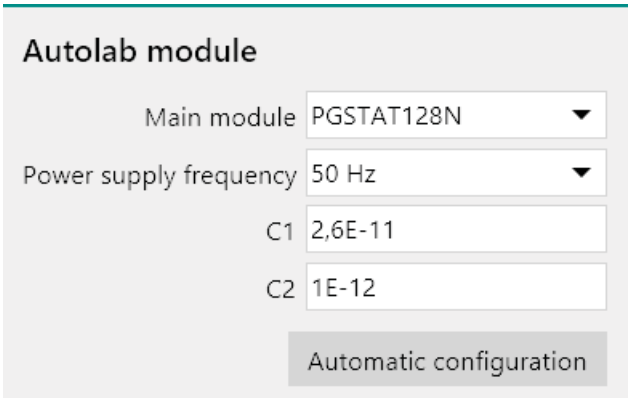


Figure 99 The Autolab module panel

5.2.2.1.2 Additional modules and properties panel

The **Additional modules** panel can be used to specify the optional modules installed in the instrument or connected to the instrument. The list of available modules depends on the main module specified in the Autolab module panel. The **Properties panel** on the right-hand side of the **Additional modules** panel can be used to specify additional properties of modules installed in the instrument or connected to the instrument *(see figure 100, page 101)*.

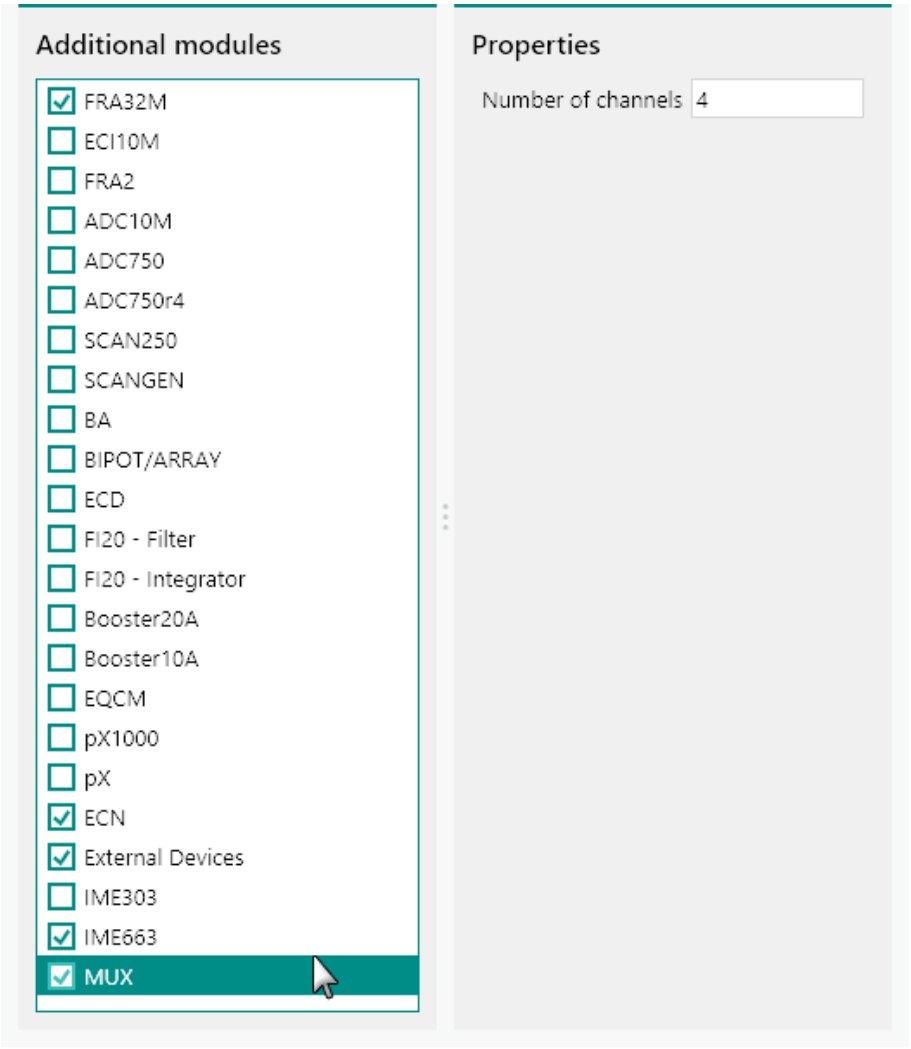


Figure 100 Optional module can be selected in the optional modules panel

NOTICE

Only the FRA2, BA, FI20 - Integrator, Booster10A, Booster20A, External Devices, IME303, IME663 and MUX module have additional properties to display in the **Properties** panel.

5.2.2.2 Current interrupt

The i-Interrupt button can be used to perform a current interrupt (i-Interrupt) measurement. This tool can be used to determine the uncompensated resistance, R_u.

NOTICE

This tool is not available for µAutolab type II and type III instrument as well as the Autolab PGSTAT10.

During a current interrupt measurement, a constant potential is applied on the cell before the current interrupt circuit is triggered. This circuit interrupts the current flow in the cell and measures the potential decay. From the measured potential decay, the uncompensated resistance (R_u) value is determined, using a linear and an exponential regression.

Two values of the uncompensated resistance, R_u, are determined automatically at the end of the measurement:

- **Ru linear:** this value is obtained from a linear regression performed on the initial segment of the voltage decay.
- **Ru exponential:** this value is obtained from an exponential regression performed on the initial segment of the voltage decay.

Proper determination of this value requires an accurate measurement of the current. The measurements must therefore be carried out at a potential value where the current is high enough to be measured properly and the current range must be adjusted in accordance.

NOTICE

For accurate measurements, the current should be at least in the order of 1 mA.

When the i-Interrupt tool is used, the control screen for this tool will be displayed *(see figure 101, page 103)*. The control screen provides two panels and one plot area.

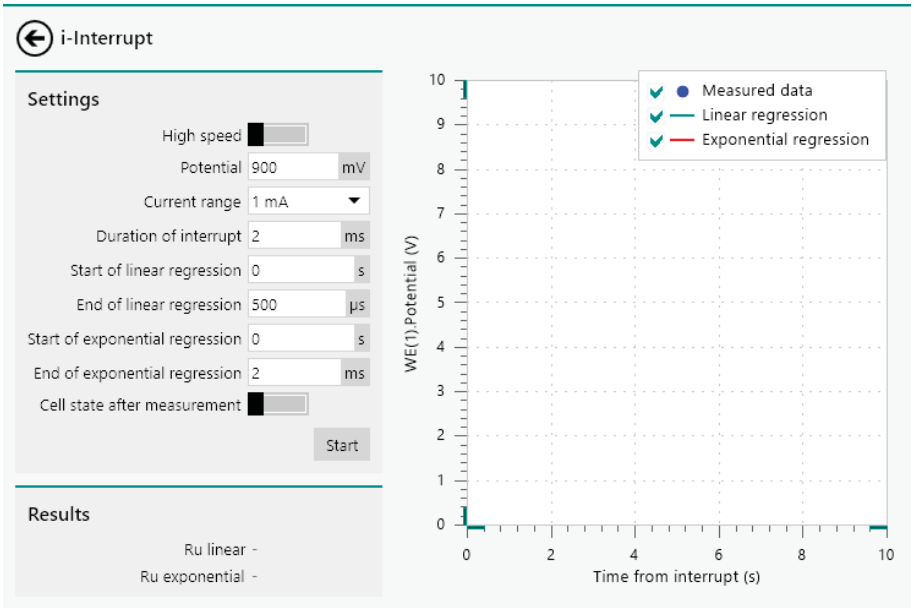


Figure 101 The i-Interrupt tool

The **Settings** panel shows the properties used in the current interrupt measurement *(see figure 102, page 103)*.

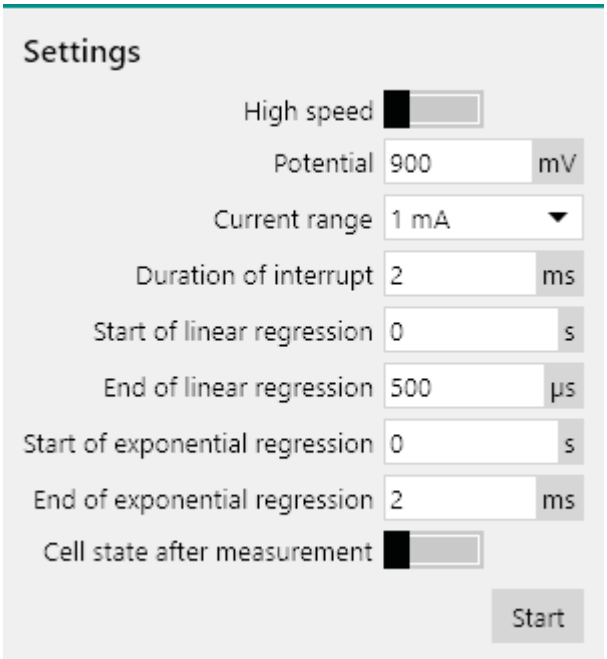


Figure 102 The i-Interrupt Settings panel

The following properties and controls are available:

- **High speed:** a toggle that can be used to switch the high speed ADC module (ADC10M or ADC750) off or on (default off).

NOTICE

This **High speed** property is only shown when the instrument is fitted with the optional **ADC10M** or **ADC750** module *ADC10M module (see chapter 16.3.2.1, page 998)*. If the instrument is fitted with this optional module it is highly recommended to use the high speed mode since it will decrease the interval time from 100 µs to 4 µs, resulting in a more reliable regression.

- **Potential:** the potential applied on the cell before the current interrupt circuit is triggered, in V.
- **Current range:** the current range in which the current interrupt measurement is performed.
- **Duration of the interrupt:** the duration of the current interrupt measurement, in s.
- **Start of linear regression:** the abscissa of the first point on the time axis relative to the start of the interrupt used for *linear* regression, in s.
- **End of linear regression:** the abscissa of the last point on the time axis relative to the start of the interrupt used for *linear* regression, in s.
- **Start of exponential regression:** the abscissa of the first point on the time axis relative to the start of the interrupt used for *exponential* regression, in s.
- **End of exponential regression:** the abscissa of the last point on the time axis relative to the start of the interrupt used for *exponential* regression, in s.
- **Cell state after measurement:** a toggle that can be used to define the state of the cell switch at the end of the measurement (default off).

Clicking the Start button initiates the current interrupt measurement, using the specified properties.

CAUTION

The current interrupt tool switches the cell on and applies a constant potential before triggering the current interrupt circuit. It is highly recommended to specify the measurement properties carefully before starting the measurement.

While the current interrupt measurement is running, the spinning symbol is shown. The instrument cannot be used until the measurement is finished. When the measurement is finished, the measured data is displayed next to the **Measurement** panel *(see figure 103, page 105)*.

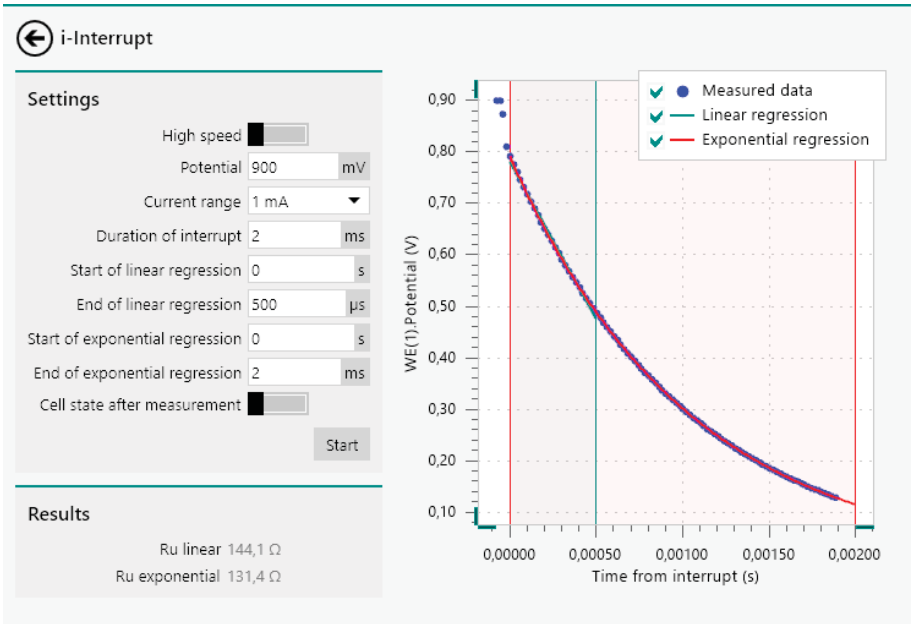


Figure 103 The measured and fitted data

The measured data points are shown as a point plot. The linear regression is shown using a green line and the exponential regression is shown as a red line. The start and end value of the two regression methods are shown using vertical lines with matching colors.

It is possible to hide or show the measured data or the regression data by checking or unchecking the check boxes shown in the legend *(see figure 104, page 105)*.

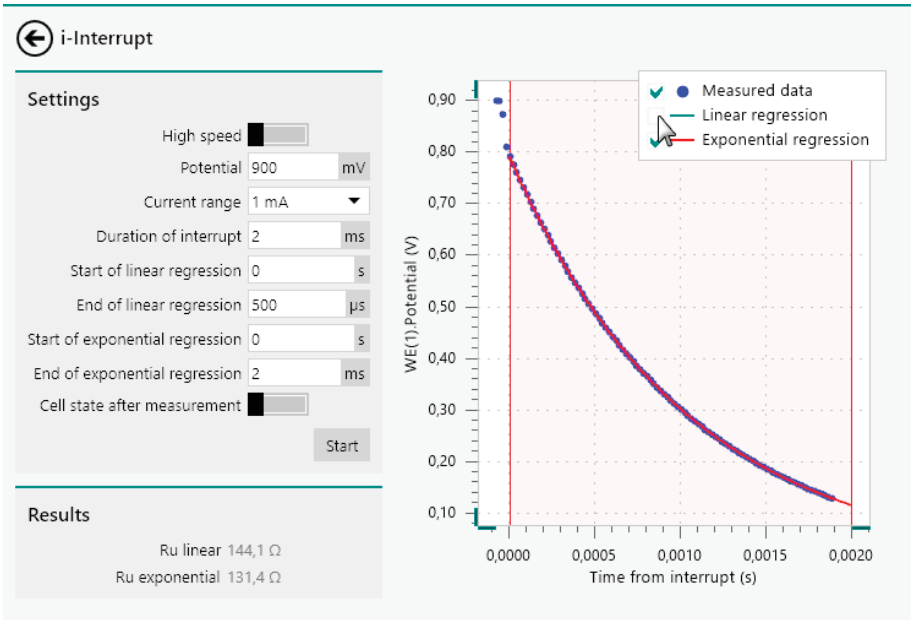


Figure 104 Using the check boxes to show or hide the data measured during the current interrupt

It is possible to fine-tune the start and stop values of both regressions by adjusting the properties in the **Settings** panel or by clicking and dragging the vertical lines *(see figure 105, page 106)*.

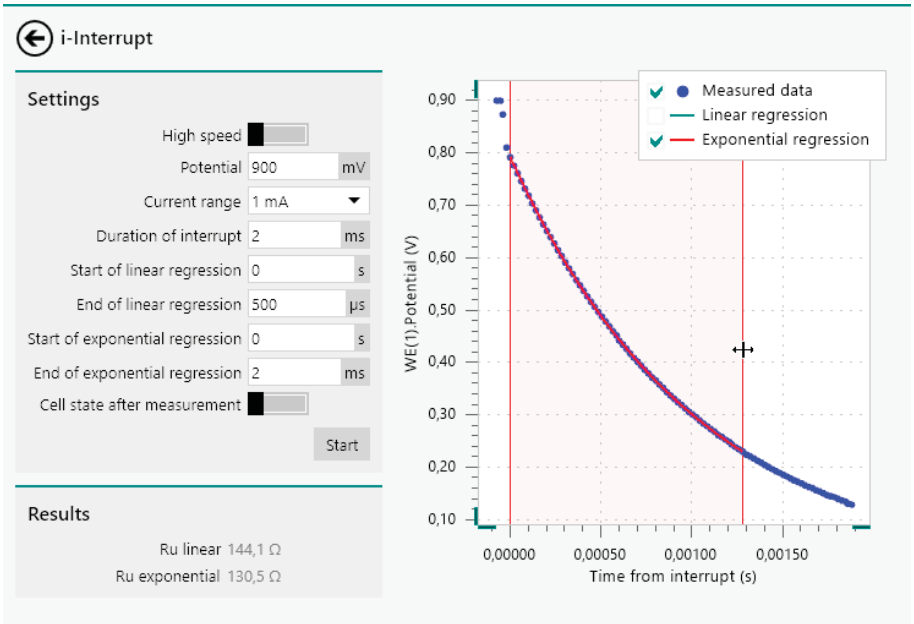


Figure 105 Fine-tuning the regression parameters

If the regression properties are adjusted after the measurement, the R_u is automatically recalculated.

The **Results** panel shows the calculated values of R_u, determined from the experimental data by linear and exponential regression *(see figure 106, page 106)*.

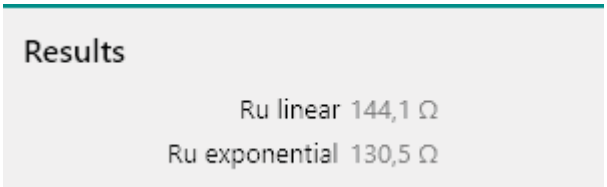


Figure 106 The fitted R_u values

It is possible to copy either one of the two values by right-clicking one of R_u values shown in the **Results** panel and using the *Copy value* option shown in the context menu *(see figure 107, page 106)*.

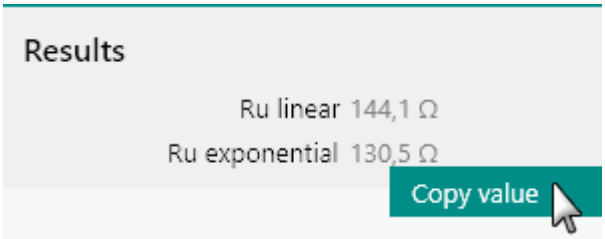


Figure 107 Copying the fitted value of R_u

NOTICE

The copied value can be pasted in a suitable property field in NOVA.

5.2.2.3 Positive feedback

The Positive feedback button can be used to perform a positive feedback measurement. This tool can be used to determine the uncompensated resistance, R_u.

NOTICE

This tool is not available for µAutolab type II and type III instrument as well as the Autolab PGSTAT10.

During a positive feedback measurement, a potential pulse is applied on the cell and the potential is recorded. The iR compensation value can be adjusted upwards manually until its value is close to the actual value of the uncompensated resistance, R_u. When the compensated resistance reaches a value close to the actual value of R_u, potentiostatic loop will start to ring. When the compensated resistance exceeds the R_u value, the potentiostatic loop is no longer stable and the instrument will oscillate.

When the positive feedback tool is used, the control screen for this tool will be displayed *(see figure 108, page 107)*. The control screen provides two panels and one plot area.

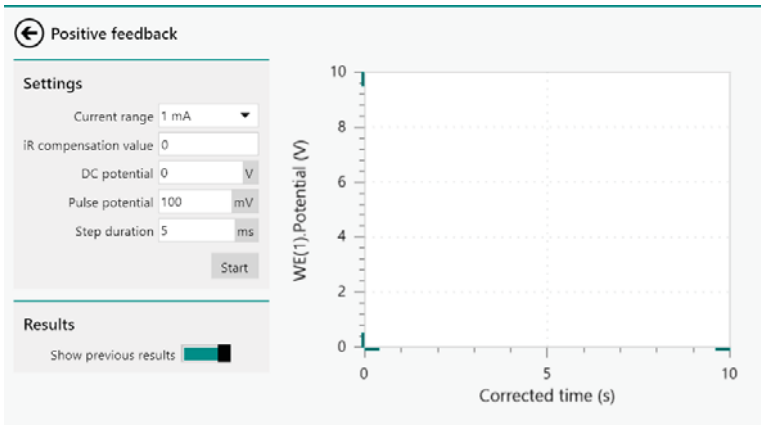


Figure 108 The positive feedback tool

The **Settings** panel shows the properties used in the current interrupt measurement *(see figure 109, page 108)*.

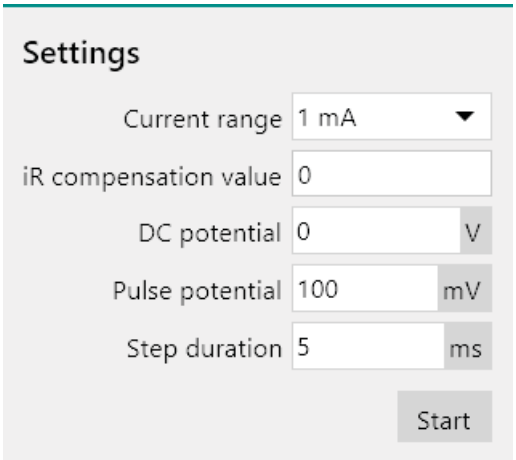


Figure 109 The positive feedback Settings panel

The following properties and controls are available:

- **Current range:** the current range in which the positive feedback measurement is performed.
- **iR compensation value:** the value of the compensated resistance, Ω.
- **DC potential:** the start and stop potential applied during the positive feedback measurement, in V.
- **Pulse potential:** the potential value applied in the pulse during the positive feedback measurement, in V.
- **Step duration:** the duration of the pulse applied during the positive feedback measurement, in s.

Clicking the Start button initiates the positive feedback measurement, using the specified properties.

CAUTION

The positive feedback tool switches the cell on and applies a potential pulse. It is highly recommended to specify the measurement properties carefully before starting the measurement.

While the positive feedback measurement is running, the spinning symbol 🗘 is shown. The instrument cannot be used until the measurement is finished. When the measurement is finished, the measured data is displayed next to the **Settings** panel *(see figure 110, page 109)*.

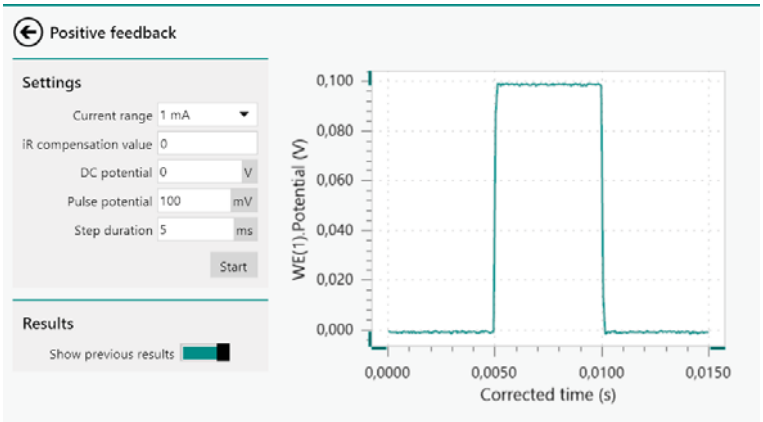


Figure 110 The measured data

The measured data shows the potential profile applied on the cell. Since the positive feedback tool uses an iterative approach, it is possible to adjust the value of the iR compensation value property and repeat the measurement *(see figure 111, page 109)*.

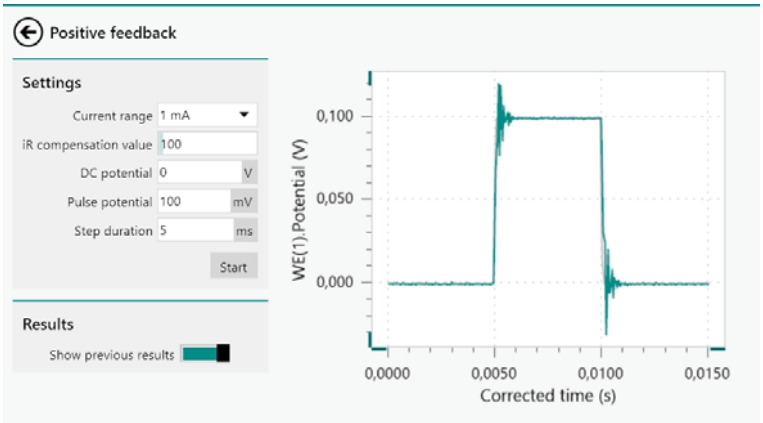


Figure 111 The measured data and previous results shown in overlay

The Show previous results toggle provided in the **Results** panel can be used to show or hide the data from the previous measurement *(see figure 112, page 109)*.

NOTICE

The tool only stores the current measured data and the data from the previous measurement.

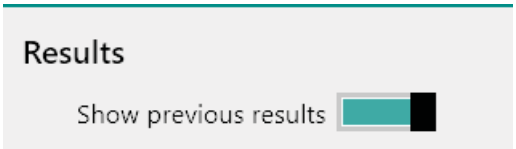


Figure 112 The previous data can be enabled and disabled

The tool can be used to test different iR compensation values. When the actual uncompensated resistance value is exceeded, the measured potential profile will become unstable and will start to oscillate *(see figure 113, page 110)*.

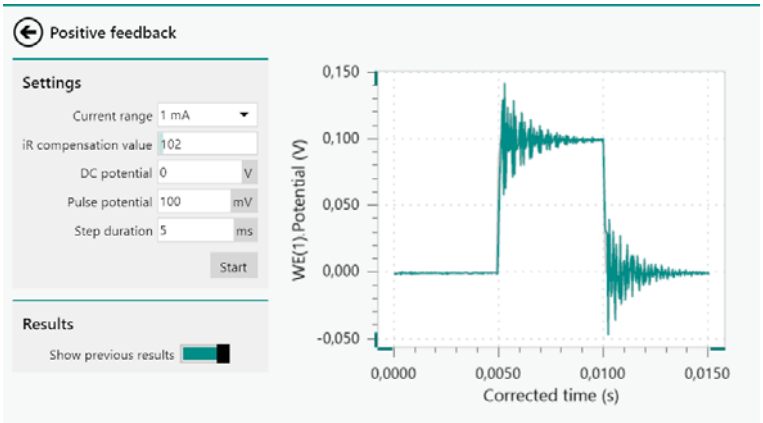


Figure 113 Oscillation is detected when the R_u value is overcompensated

NOTICE

Whenever using the iR drop compensation is used in any electrochemical measurement, it is recommended to set the compensated resistance to about 80-90 % of the estimated R_u value.

5.2.2.4 Check cell

The Check cell button can be used to perform a cell check. This tool can be used to evaluate the cell connections, test the stability of the feedback loop and evaluate the noise levels.

During a cell check, five consecutive, high-speed current measurements are carried out at the specified potential or current. The software will evaluate the stability of the feedback loop of the instrument and determine the average value and standard deviation of the measured current or potential. The presented results can be used to assess the quality of the cell connections and the noise levels.

NOTICE

The duration of each measurement is determined by the **Power supply frequency** property. With 50 Hz, each measurement will take 20 ms. With 60 Hz, each measurement will take 16.66 ms.

When the check cell tool is used, the control screen for this tool will be displayed *Figure 114*. The control screen provides two panels and one plot area.

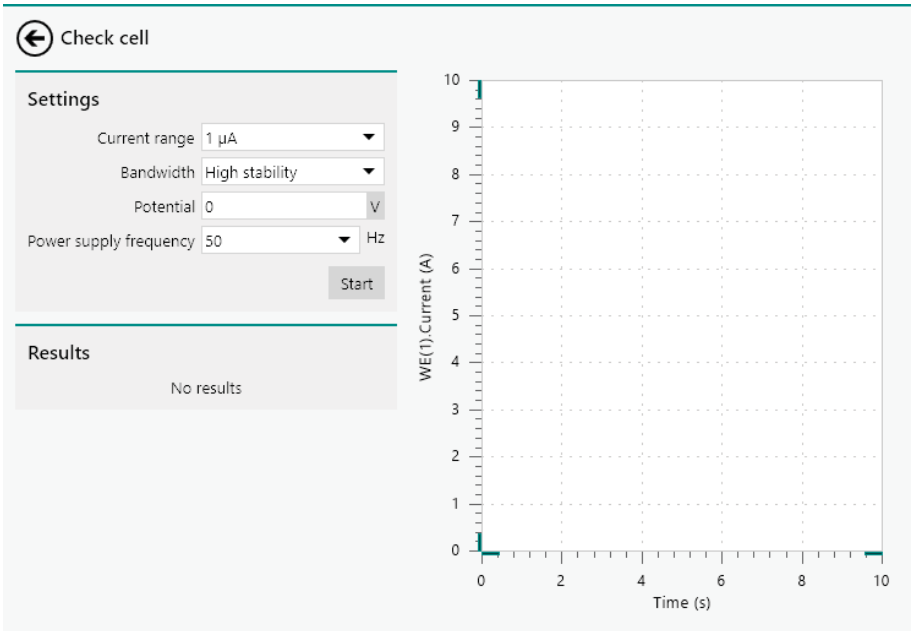


Figure 114 The check cell tool

The **Settings** panel shows the properties using the cell check measurement *(see figure 115, page 111)*.

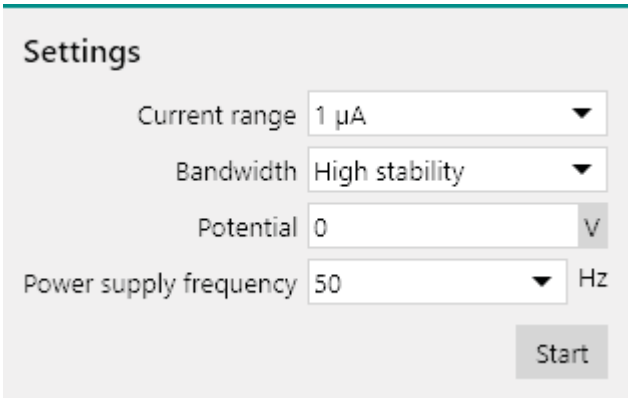


Figure 115 The check cell Settings panel

The following properties and controls are available:

- **Current range:** the current range in which the cell check is performed.
- **Bandwidth:** a drop-down control that can be used to specify the bandwidth of the instrument (high stability, high speed or ultra-high speed).
- **Potential/Current:** a numeric field that can be used to specify the applied potential (in potentiostatic mode) or the applied current (in galvanostatic mode).

- **Power supply frequency:** specifies if the mains frequency is 50 or 60 Hz.

NOTICE

More information on the instrument bandwidth settings can be found in *Chapter 16.1.2.3*.

Clicking the Start button initiates the cell check measurement, using the specified properties.

While the cell check measurement is running, the spinning symbol is shown. The instrument cannot be used until the measurement is finished. When the measurement is finished, the measured data is displayed next to the **Settings** panel and the average and standard deviation of the data is reported in the **Results** panel *(see figure 116, page 112)*.

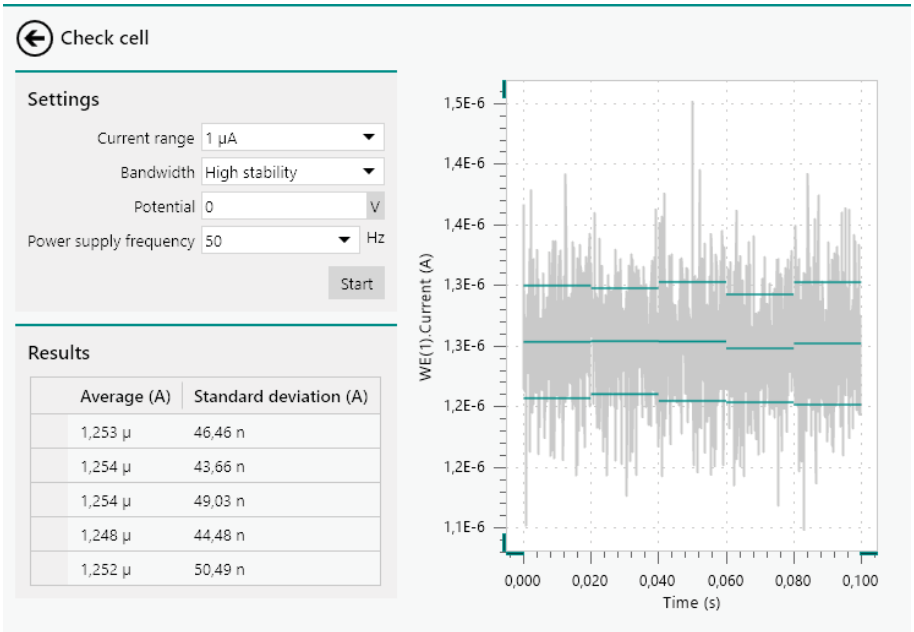


Figure 116 The measured data and the results are shown after the measurement

The data plotted in light grey corresponds to the raw current data measured during the cell check. For each of the five consecutive measurements, the average value and the standard deviation is graphically reported in the plot, in dark green.

The check cell tool calculates the average value of the measured standard deviations, $\bar{\sigma}$, and uses this value to evaluate if the measured current noise is within acceptable limits for the used current range, [CR], according to: