1 – The Autolab control command

The Autolab control command is one of the most important commands in the NOVA software. Through this command, all of the hardware settings of the Autolab PGSTAT and the modules can be set, at any time during a measurement. This command is also used to set the properties of the instrument at the end of an experiment, or when an experiment is interrupted by a user or a cutoff condition.

The Autolab control command is located in the Measurement – General group of commands.

Scope of the tutorial

The aim of this tutorial is to explain how to use the Autolab control to set the properties of the Autolab PGSTAT. Special attention is given to each of the settings and to the use of the Autolab control command in the End status Autolab in the procedure editor.

2 – Using the Autolab control command

To use the Autolab control command in NOVA, this command must be added to the procedure (see Figure 1).

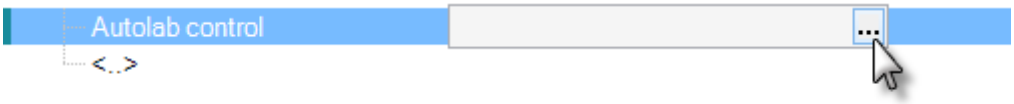

Figure 1 – The Autolab control command

To edit the settings available in the Autolab control command, click the ... button located in the procedure editor (see Figure 1). This opens the Autolab control window (see Figure 2).

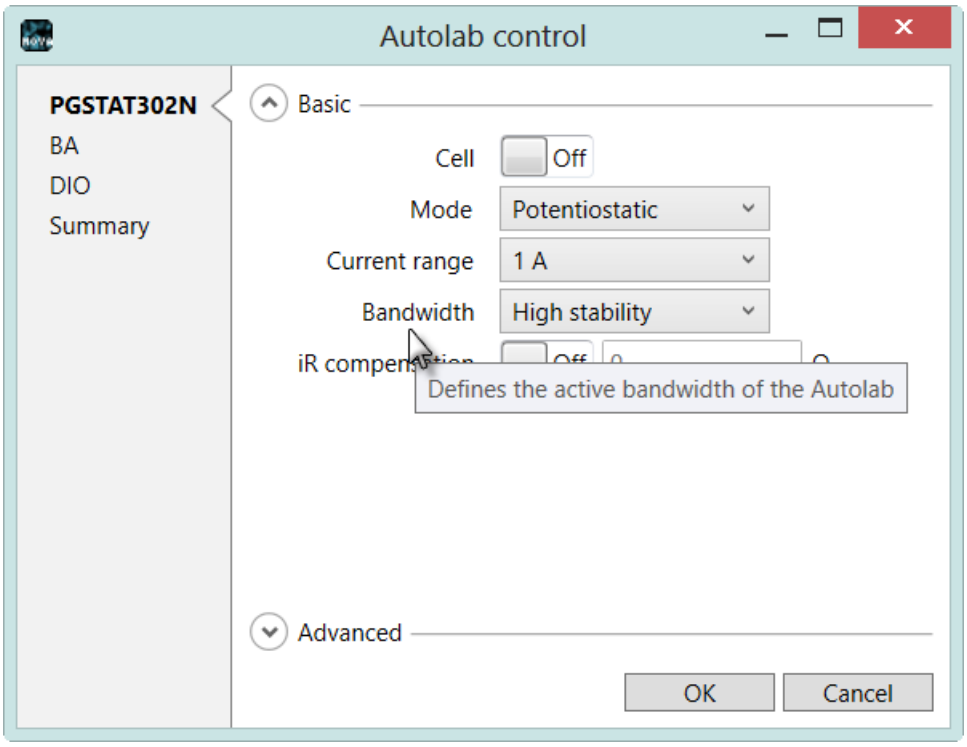

Figure 2 – The Autolab control window

Three different default sections are located in the Autolab control window, on the left-hand side[1]:

- **PGSTAT302N[2]:** this section is used to define all the settings of the main working electrode and the Autolab. The settings are displayed in two panels: Basic and Advanced.
- **DIO:** this section is used to set the settings of the digital input/outputs of the Autolab[3].
- **Summary:** this section is used to display the summary of all the settings defined with the Autolab control command.

Depending on the hardware setup, additional sections can be available in the Autolab control window. Figure 2 displays one additional section for the **BA** module.

Note

A tooltip is provided for each setting in the Autolab control window (see Figure 2).

[1] If other optional modules are selected in the Hardware setup, additional sections will be shown in the Autolab control window.
[2] The name of this section depends on the type of instrument specified in the hardware setup.
[3] More information on the use of the DIO can be found in the External devices tutorial.

2.1 – Invalid settings

When invalid settings are defined in the Autolab control command, for example using a procedure that includes settings incompatible with the instrument connected to the computer, the Autolab control window will automatically open on the summary section, highlighting the invalid settings in red (see Figure 3).

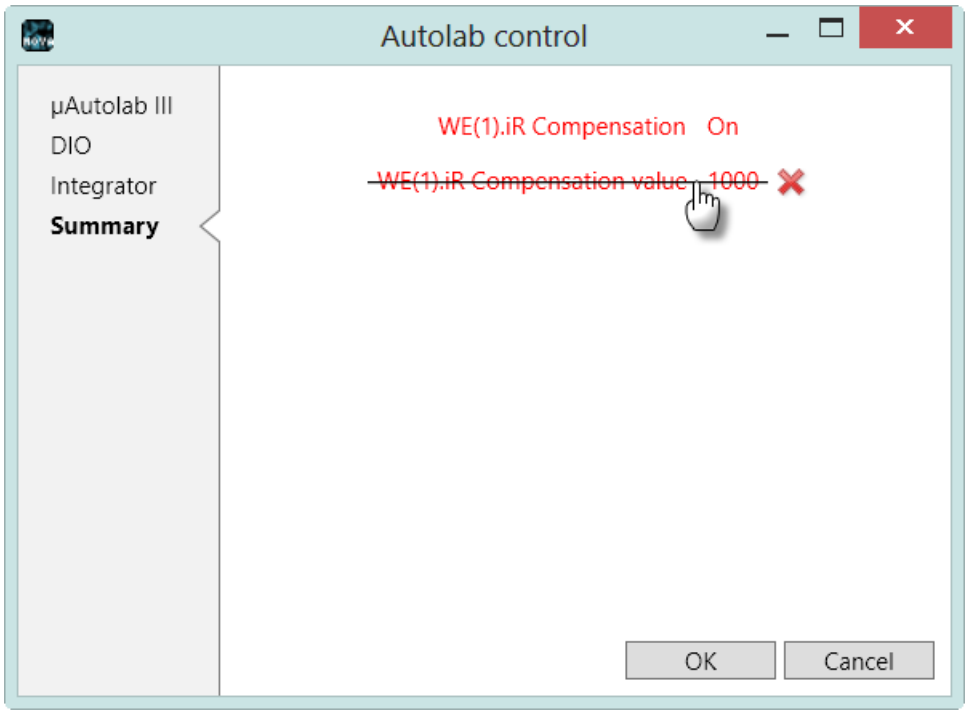

Figure 3 – Invalid settings are displayed in the summary section, in red

To remove the invalid settings, click the setting as shown in Figure 3. It will be deleted from the Autolab control.

3 – Autolab PGSTAT settings

The settings for the main Autolab potentiostat/galvanostat are defined in the first section of the Autolab control window. This section is identified by the name of the type of instrument specified in the hardware setup.

The Autolab settings are specified in two different panels:

- **Basic:** the most common settings of the instrument.
- **Advanced:** special settings relevant for special applications.

The Autolab control window always opens with the Basic section active.

3.1 – Basic settings

The following basic settings can be specified using the Autolab control command:

- **Cell (On/Off):** switches the Autolab PGSTAT cell switch on or off.
- **Mode (Potentiostatic/Galvanostatic):** defines the mode of the PGSTAT.
- **Current range:** defines the current range for Autolab PGSTAT. The available current ranges depend on the hardware setup. The optional ECD module extends the current range down to 100 pA and the Booster extends the current range up to 20 A (see Figure 4).

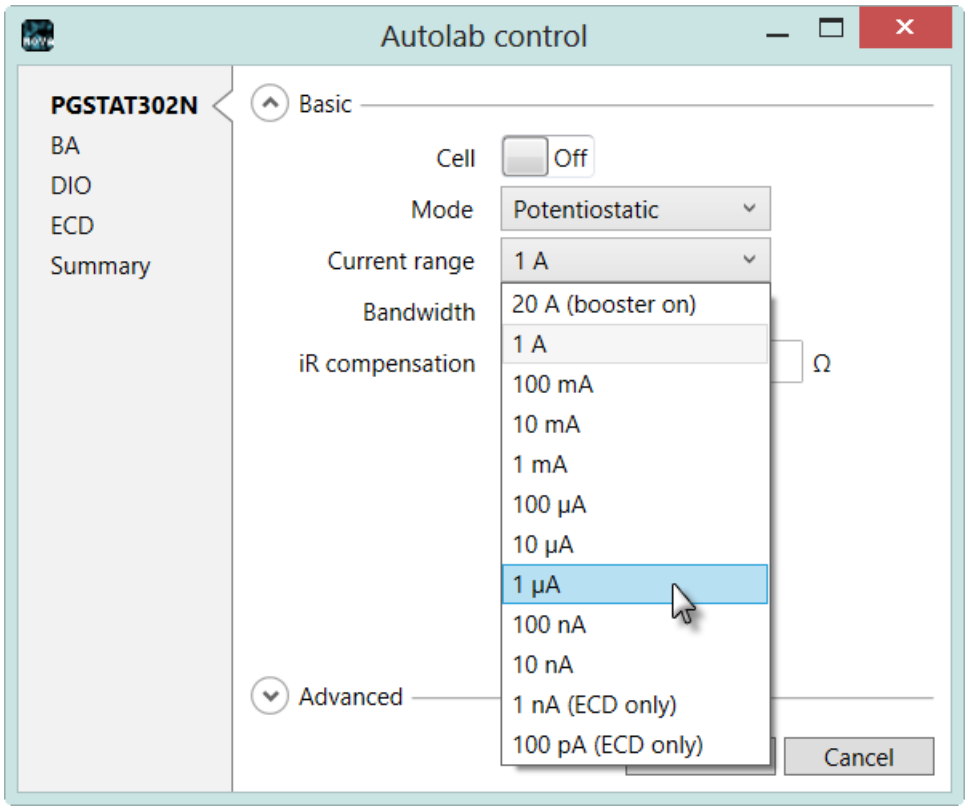

Figure 4 – The available current ranges depend on the hardware setup

Note

The current defined in the Autolab control is the current range that should be selected when the Autolab control command is executed during the measurement. If the Automatic current ranging option is used during the measurement, it is possible that another current range will be used in the experiment.

- **Bandwidth:** defines the bandwidth of the Autolab PGSTAT: three settings are available: high stability, high speed and ultra-high speed[4].
- **iR Compensation (On/Off):** switches the iR compensation circuit on or off[5].
- **iR Compensation value:** defines the value of the compensated resistance used in the iR compensation circuit[5]. The value range depends on the active current range.

3.2 – Advanced settings

The Advanced settings panel can be displayed by clicking the ⌄ button in the Autolab control window (see Figure 5).

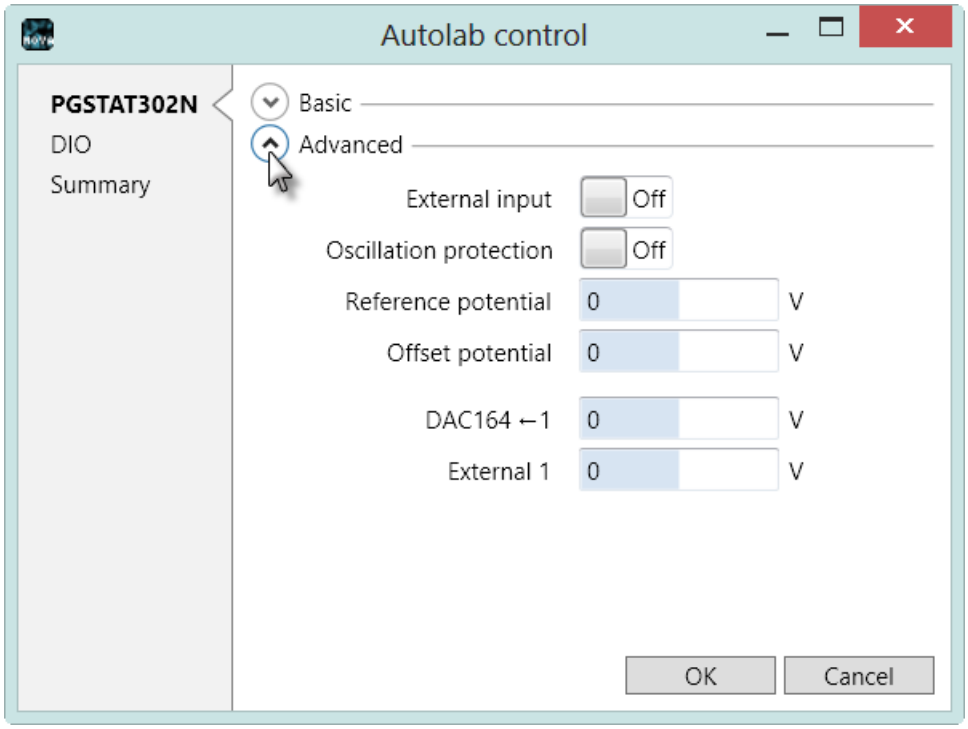

Figure 5 – The Advanced settings panel of the Autolab control command

[4] More information on the bandwidth settings of the Autolab PGSTAT can be found in the NOVA Getting started.
[5] Not available on the PGSTAT10 and the µAutolab II/III.

The following advanced settings can be specified using the Autolab control command:

- **External input (On/Off):** switches the external input of the PGSTAT on or off[6].
- **Oscillation protection (On/Off):** switches the oscillation protection circuit on or off[6].
- **Reference potential:** defines the value of the reference voltage.
- **Offset potential:** defines the value of the offset DAC of the Autolab.
- **DAC164 ←1:** defines the output voltage of the DAC164 module, BNC output #1.
- **External 1:** defines the converted output voltage of the DAC164 module, BNC output #1 used to control the external device defined in the hardware setup.

Depending on the hardware setup, additional settings can be defined in the Advanced panel (see Figure 6).

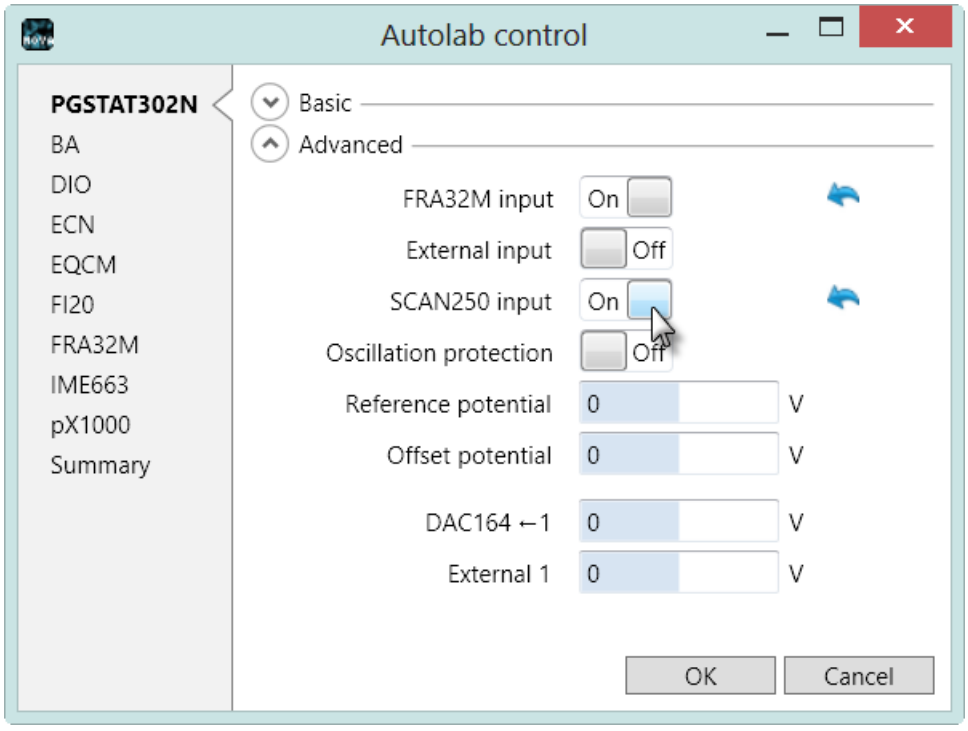

Figure 6 – Additional module settings are available on the Advanced panel

- **FRA32M/FRA2 input (Enabled/Disabled):** enables or disables the FRA32M or FRA2 module input on the summation point of the PGSTAT.
- **SCAN250/SCANGEN input (Enabled/Disabled):** enables or disables the linear scan generator module (SCAN250 or SCANGEN) input on the summation point of the PGSTAT.

[6] Not available on the PGSTAT10, PGSTAT20, µAutolab II/III, PGSTAT101/M101 and PGSTAT204.

Note

The Autolab control settings required to use the FRA32M or FRA2 module and the SCAN250 or SCANGEN module are already included in the related commands (FRA measurement potentiostatic, FRA measurement galvanostatic, FRA measurement external, CV linear scan and CV linear scan high speed).

4 – µAutolab II/III settings

4.1 – Basic settings

When the µAutolab type II or III is used, the following basic settings are available (see Figure 7):

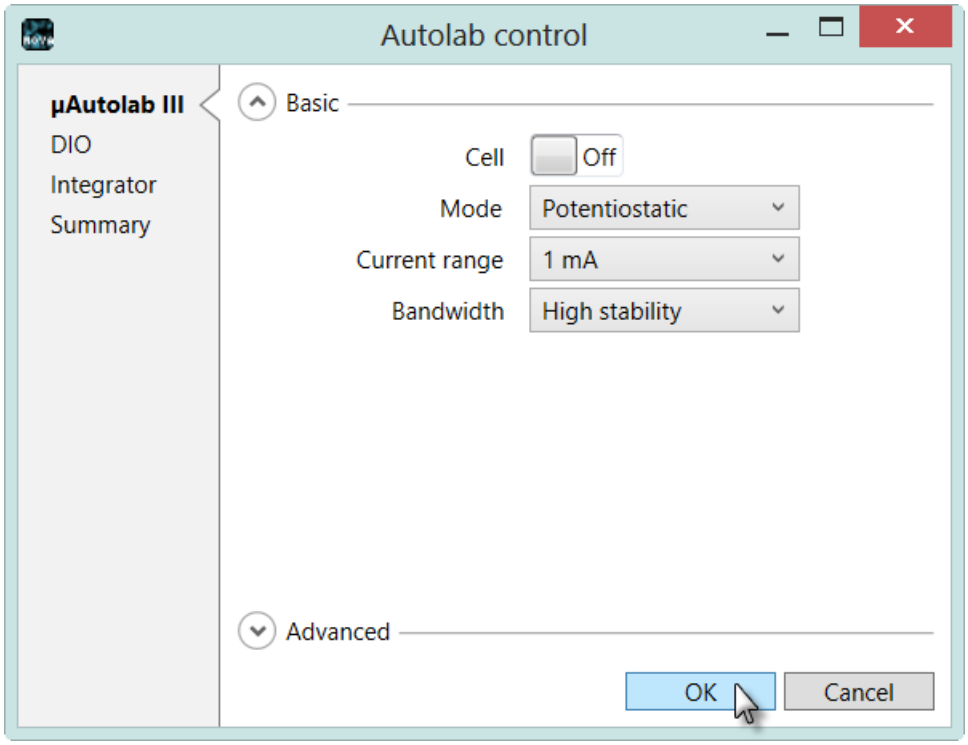

Figure 7 – The basic settings for the µAutolab

- **Cell (On/Off):** switches the µAutolab cell switch on or off.
- **Mode (Potentiostatic/Galvanostatic):** defines the mode of the µAutolab.
- **Current range:** defines the current range for µAutolab.
- **Bandwidth:** defines the bandwidth of the µAutolab: two settings are available: high stability and high speed[7].

[7] More information on the bandwidth settings of the µAutolab can be found in the NOVA Getting started.

4.2 – Advanced settings

The Advanced settings panel can be displayed by clicking the ⌄ button in the Autolab control window (see Figure 8).

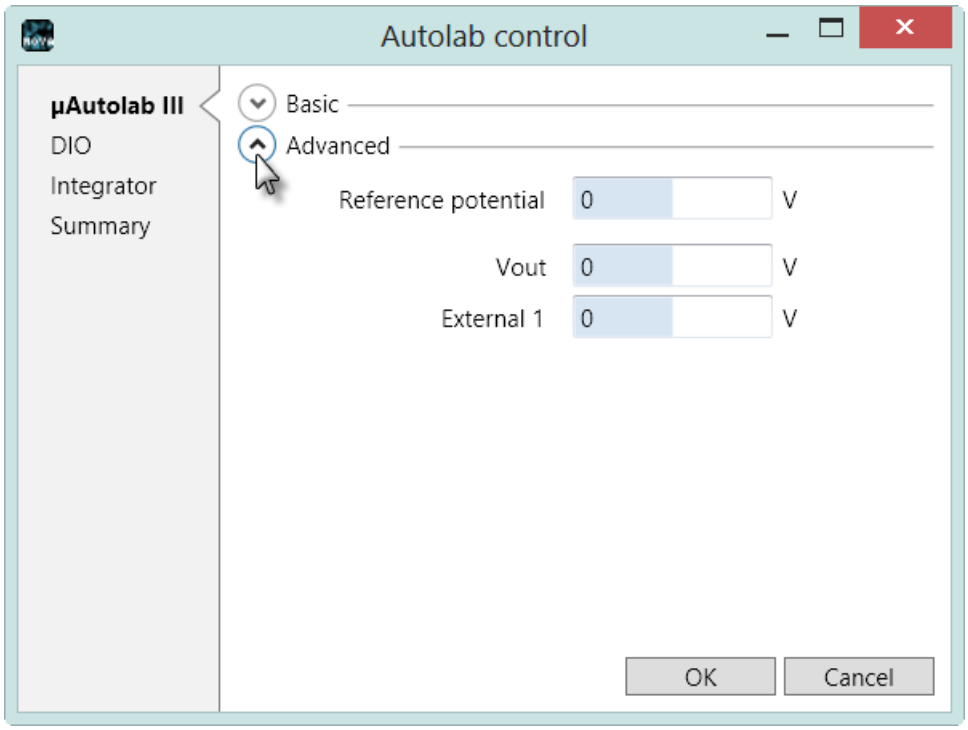

Figure 8 – The advanced settings of the μAutolab

The following advanced settings can be specified using the Autolab control command:

- **Reference voltage:** defines the value of the reference voltage.
- **Vout:** defines the output voltage of the Vout BNC output located on the backplane of the μAutolab.
- **External 1:** defines the converted output voltage of the Vout BNC output located on the backplane of the μAutolab used to control the external device defined in the hardware setup.

5 – PGSTAT101, PGSTAT204, M101 or M204 settings

5.1 – Basic settings

When the PGSTAT101, PGSTAT204, M101 or M204 is used, the following basic settings are available (see Figure 9):

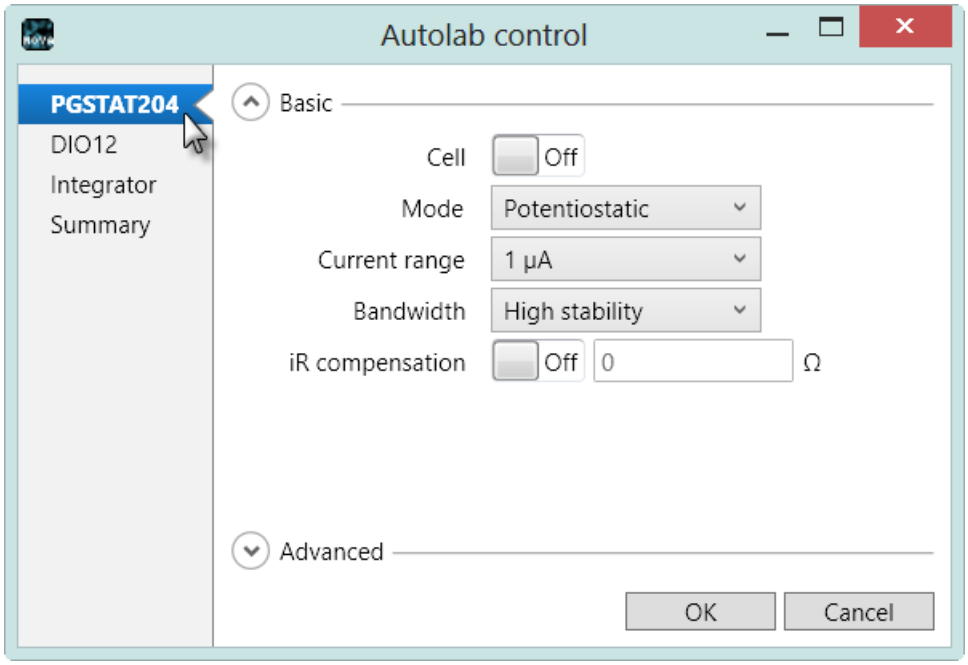

Figure 9 – The basic settings for the PGSTAT101 or M101

- **Cell (On/Off):** switches the Autolab PGSTAT101/PGSTAT204/M101/M204 cell switch on or off.
- **Mode (Potentiostatic/Galvanostatic):** defines the mode of the PGSTAT101, PGSTAT204, M101 or M204.
- **Current range:** defines the current range for Autolab PGSTAT101, PGSATT204, M101 or M204.
- **Bandwidth:** defines the bandwidth of the PGSTAT101, PGSTAT204, M101 or M204: three settings are available: high stability, high speed and ultra-high speed[8].
- **iR Compensation (On/Off):** switches the iR compensation circuit on or off.
- **iR Compensation value:** defines the value of the compensated resistance used in the iR compensation circuit[5]. The value range depends on the active current range.

[8] More information on the bandwidth settings of the PGSTAT101/PGSTAT204/M101/M204 can be found in the NOVA Getting started.

5.2 – Advanced settings

The Advanced settings panel can be displayed by clicking the ⌄ button in the Autolab control window (see Figure 10).

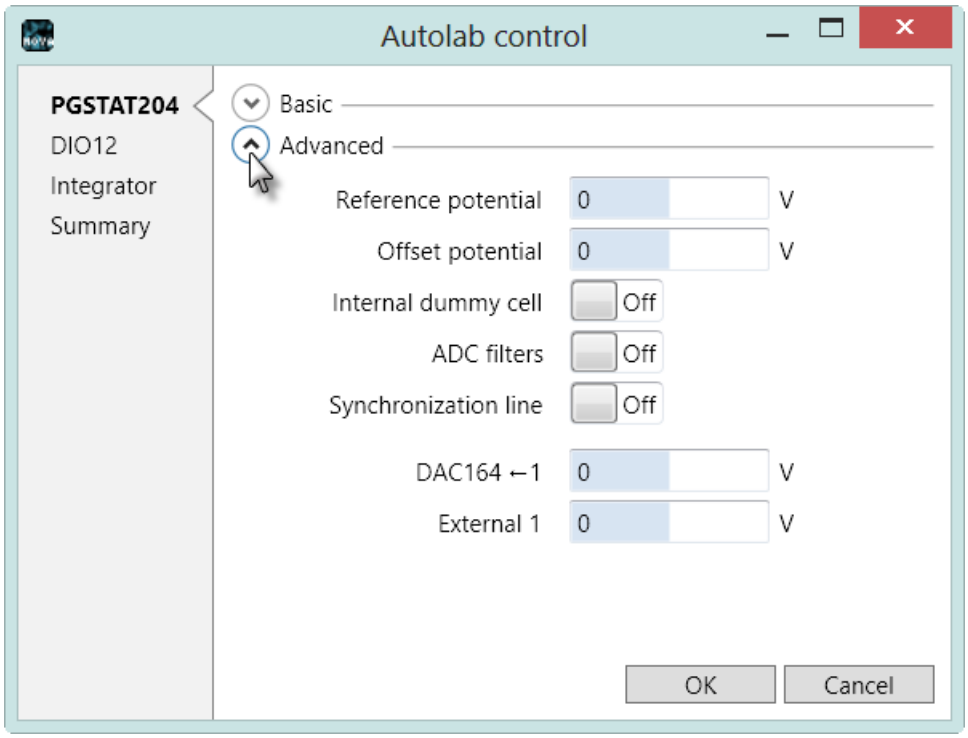

Figure 10 – The advanced settings for the PGSTAT101/M101

- **Reference voltage:** defines the value of the reference voltage.
- **Offset.Value:** defines the value of the offset DAC of the Autolab.
- **Internal dummy cell (On/Off):** switches the internal dummy cell on or off.
- **ADC filters:** specifies the status of the ADC filters (On/Off). When the filter is On, a low pass filter with a cutoff frequency of 22 kHz is applied on the input signals of the ADC.
- **Synchronization line:** defines the status of the synchronization line[9] used in Multi Autolab measurements. Setting the bit ON enables hardware synchronization[10].
- **Vout:** defines the output voltage of the Vout BNC output located on the optional monitor cable[11] of the PGSTAT101, PGSTAT204, M101 or M204.
- **External 1:** defines the converted output voltage of the Vout BNC output located on the optional monitor cable[11] of the PGSTAT101, PGSTAT204, M101 or M204 used to control the external device defined in the hardware setup.

[9] This is only functional in the M101 or M204 modules installed in the Multi Autolab cabinet.
[10] More information on the use of the synchronization line can be found in the Multi Autolab tutorial, available from the Help menu.
[11] More information on the optional monitor cable for the PGSTAT101, PGSTAT204, M101 or M204 module can be found in the Getting Started manual.

6 – Using the Autolab control command

The settings available in the Autolab control can be defined during an electrochemical measurement by adding the Autolab control command in the procedure, whenever one of properties of the instruments needs to be changed.

The Autolab cyclic voltammetry potentiostatic procedure provides a good example of the use of the Autolab control command at the beginning of the procedure (see Figure 11).

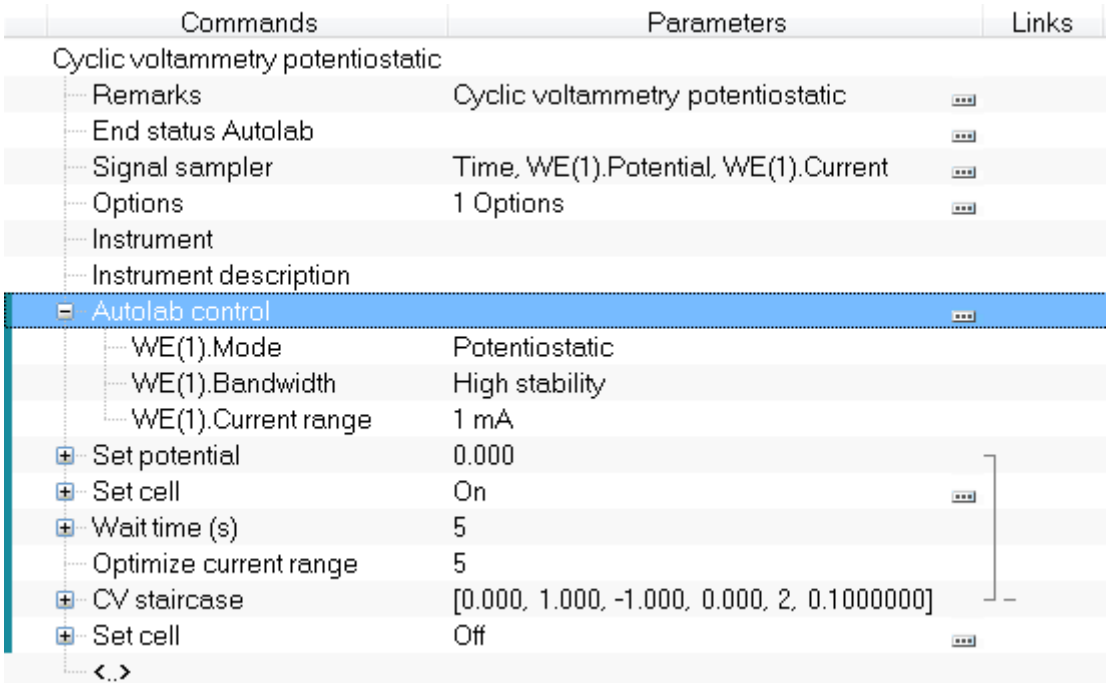

Figure 11 – The Autolab Cyclic voltammetry potentiostatic procedure

In this procedure, the Autolab control command is used to specify the initial settings of the instrument. The following properties are defined in the command:

- **WE(1).Current range:** 1 mA
- **WE(1).Bandwidth:** High stability
- **WE(1).Mode:** Potentiostatic

These settings are displayed in the procedure editor, below the Autolab control command (see Figure 12).

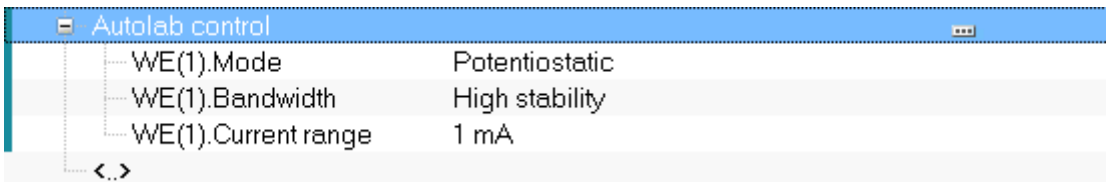

Figure 12 – The settings defined in the Autolab control command are displayed in the procedure editor

Changing the settings in the Autolab control command can be done by clicking the ... button. The Autolab control window will appear, displaying the settings defined in the command. All settings that have button indicated on the right in the Autolab control window are specifically defined in the Autolab control command (see Figure 13).

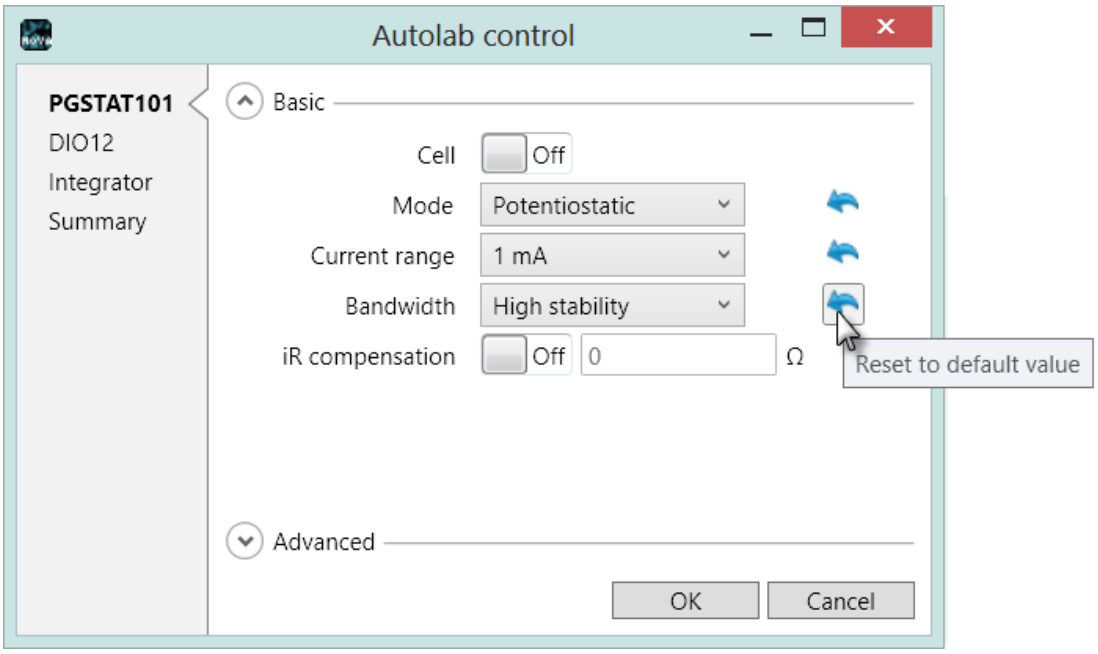

Figure 13 – The settings specified in the Autolab control are identified by a button

Changing the initial current range from 1 mA to 100 µA can be done using the dropdown list (see Figure 14).

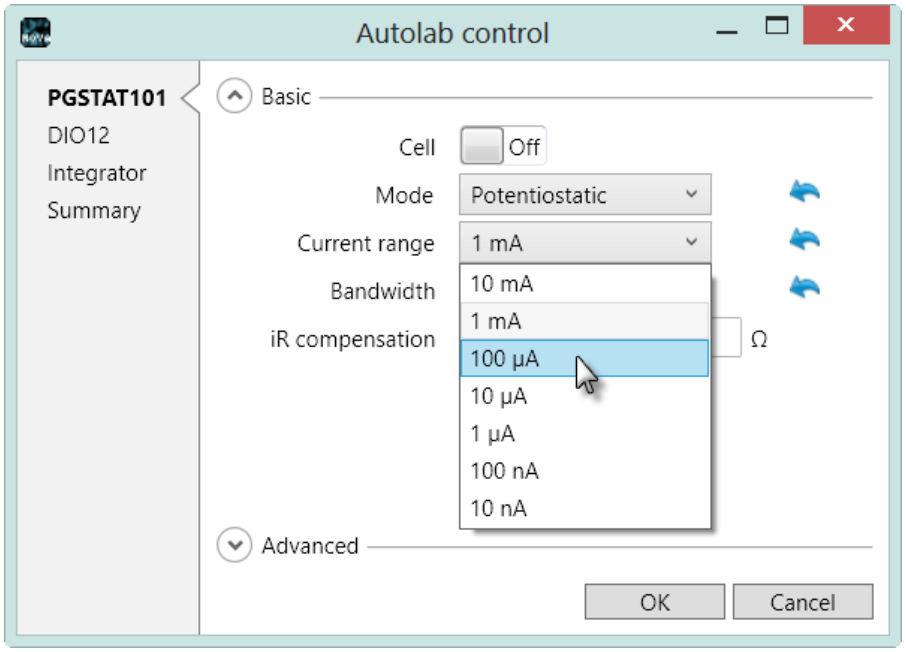

Figure 14 – Changing the current range can be done using the dropdown list

Clicking the button located next to the properties specified in the Autolab control command changes the property to the current value of the instrument (see Figure 15).

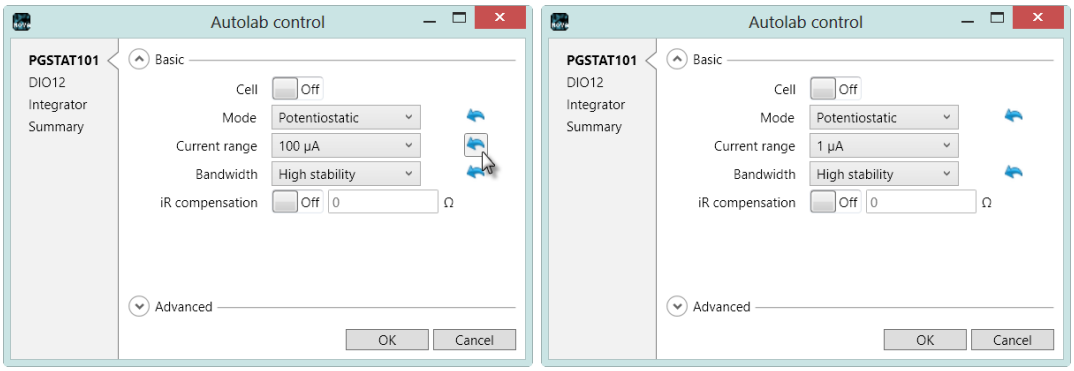

Figure 15 – Clicking the sets the property to the active value on the instrument (active current range on the instrument: 1 µA)

Click the OK button after the settings have been changed. The Autolab control command will be updated in the procedure editor (see Figure 16).

Commands	Parameters	Links
Cyclic voltammetry potentiostatic		
Remarks	Cyclic voltammetry potentiostatic	
End status Autolab		
Signal sampler	Time, WE(1).Potential, WE(1).Current	
Options	1 Options	
Instrument	AUT40034	
Instrument description		
Autolab control		
WE(1).Mode	Potentiostatic	
WE(1).Bandwidth	High stability	
Set potential	0.000	
Set cell	On	
Wait time (s)	5	
Optimize current range	5	
CV staircase	[0.000, 1.000, -1.000, 0.000, 2, 0.1000000]	
Set cell	Off	
<..>		

Figure 16 – The modified Autolab Cyclic voltammetry procedure: the initial current range has been reset to default (1 µA)

Additional settings can be defined, using an existing Autolab control command located in the procedure editor or by adding additional Autolab control commands to the procedure.

Keep in mind that the settings defined in the Autolab control command are all set when the procedure executes the command[12].

Figure 17 shows the Autolab cyclic voltammetry procedure with two additional settings defined in the Autolab control command:

- iR Compensation: On
- iR Compensation value: 100

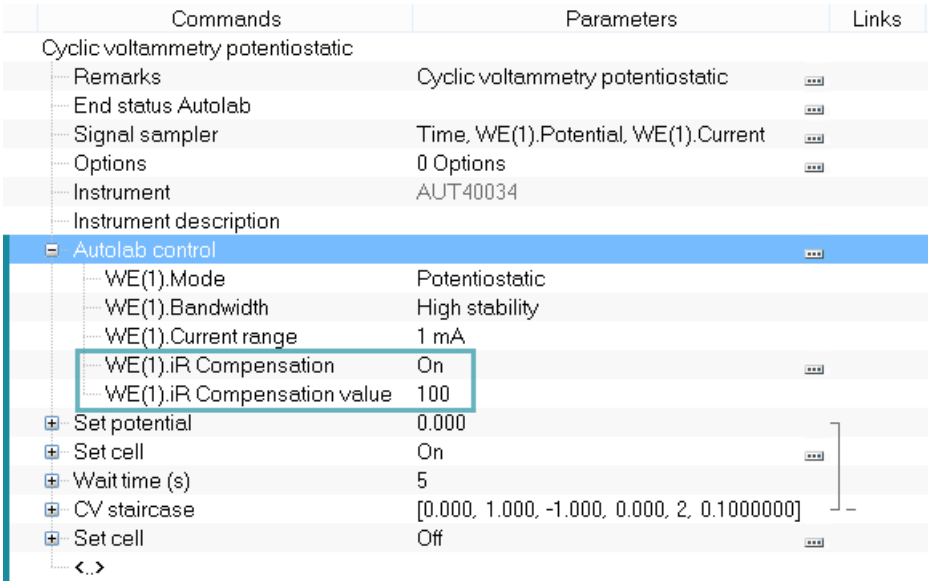

Figure 17 – The Autolab cyclic voltammetry potentiostatic procedure modified using the Autolab control command: the iR compensation circuit is switched on and the iR compensation value is set to 100 Ohm

The parameters of the Autolab control shown in the procedure editor can be linked to control commands like an Input box or a Repeat for each value command (see Figure 18).

[12] The settings defined in the Autolab control are set sequentially in order to avoid possible hardware conflicts.

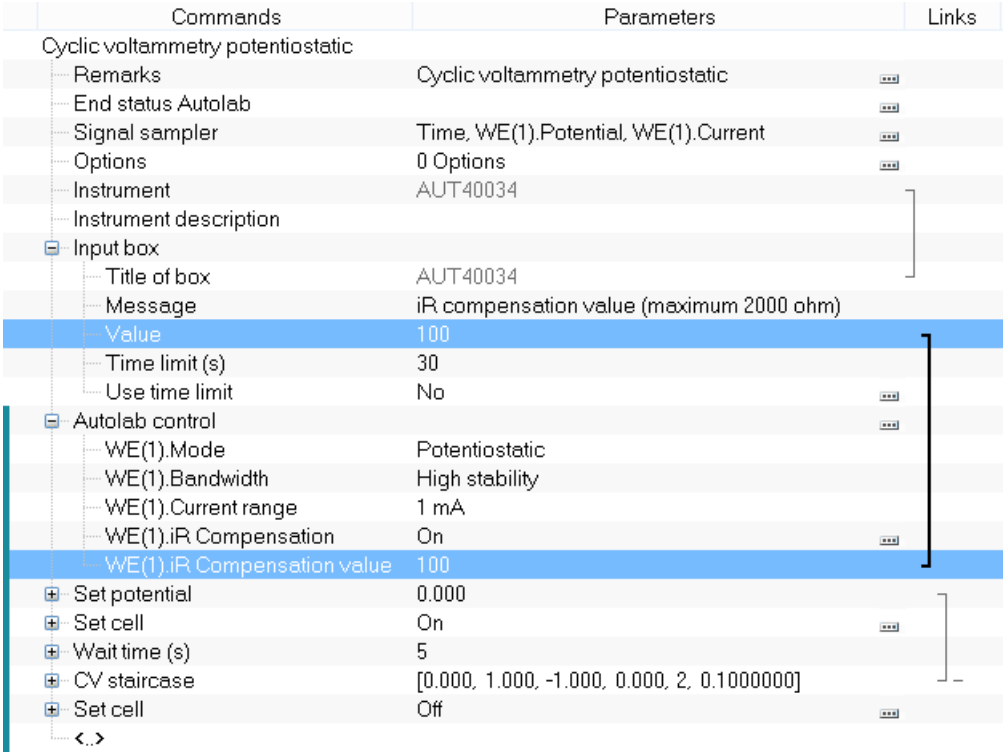

Figure 18 – Using an input box in combination with the Autolab control command

7 – End status Autolab

The End status Autolab instruction is always present in the header of the procedure, alongside the title, the remarks field, the signal sampler, the options, instrument description and serial number field (see Figure 19).

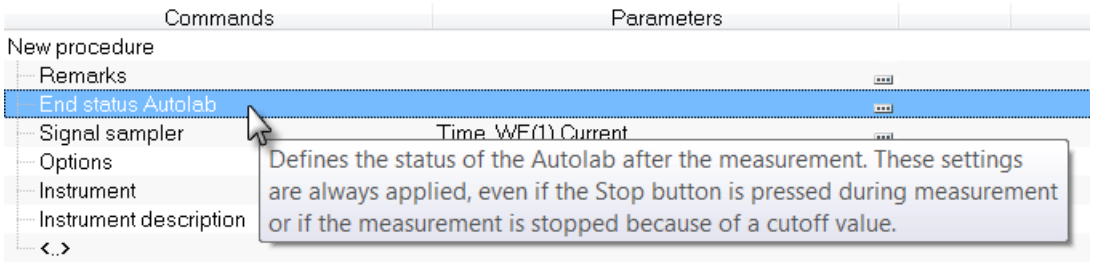

Figure 19 – The End status Autolab is located in the header of any procedure

The End status Autolab is a special Autolab control command which can be used to define the settings of the Autolab whenever a measurement stops.

This command is always the last executed command and it is triggered by the following events:

- **The measurement finishes normally:** before the data is saved in the dasectionase, the End status Autolab command is executed, setting the final properties of the instrument.
- **A cutoff condition is encountered:** if a cutoff condition designed to stop the complete procedure is triggered during the measurement, the procedure stops immediately, sets the instrument according to the End status Autolab command and stores the data in the dasectionase.
- **The user stops the measurement:** if the user interrupts the measurement by pressing the stop button, the procedure is stopping as soon as possible, the instrument is set to the status defined in the End status Autolab command and the data is stored in the database.

To edit the End status Autolab command, click the ... button located next to the command in the procedure editor (see Figure 20).

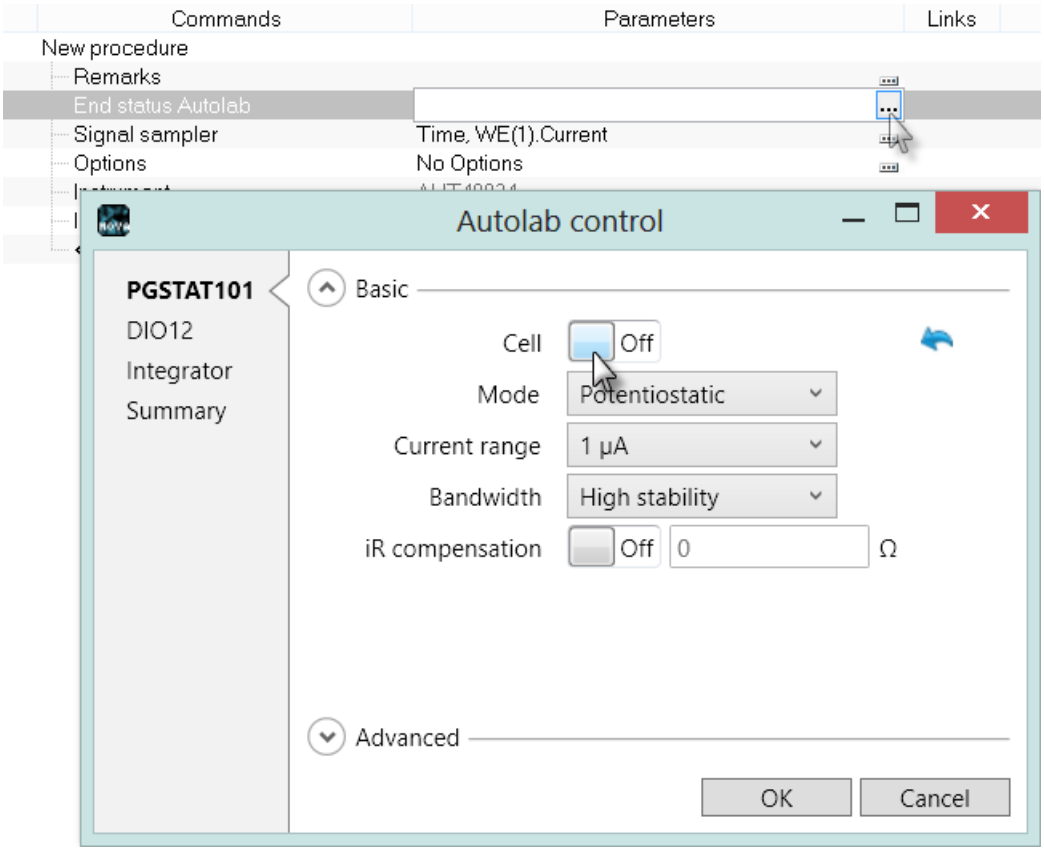

Figure 20 – Using the End status Autolab control to set the Cell off at when the measurement stops

8 – Extended voltage range

The voltage setting of the Autolab PGSTAT[13] is defined by the sum of two DAC channels internally connected to the summation point of the control amplifier. One of the DAC is called the *Scanning DAC* and the other DAC is called the *Offset DAC*. Both DAC's have a range of ± 5 V. The scanning DAC can be modified during an electrochemical measurement, while the offset DAC can only be modified when the cell is switched off, to prevent interference with the ongoing measurement.

In practice this means that the potential range of the Autolab will be ± 5 V with respect to the value of the offset DAC.

The startup settings of the Autolab PGSTAT are the following:

- Scanning DAC: 0 V
- Offset DAC: 0 V

Using these initial settings, the Autolab PGSTAT is capable of applying any voltage value in the -5 V to 5 V range (with respect to the offset DAC value of 0 V). To apply a voltage outside of this potential range, the offset DAC value must be adjusted.

For example, to apply 7 V on the cell during an electrochemical measurement, the following settings can be used[14]:

- Scanning DAC: 2 V
- Offset DAC: 5 V

Using these settings, the Autolab PGSTAT can be used to set the potential of the working electrode to any value between 5 V and 10 V during an electrochemical measurement.

Using the Autolab display, it is possible to manually control the potential or current applied. The offset DAC will be automatically adjusted to the required value depending on the specified potential or current (see Figure 21).

[13] This does not apply for the µAutolab II and III.
[14] Other combinations are possible.

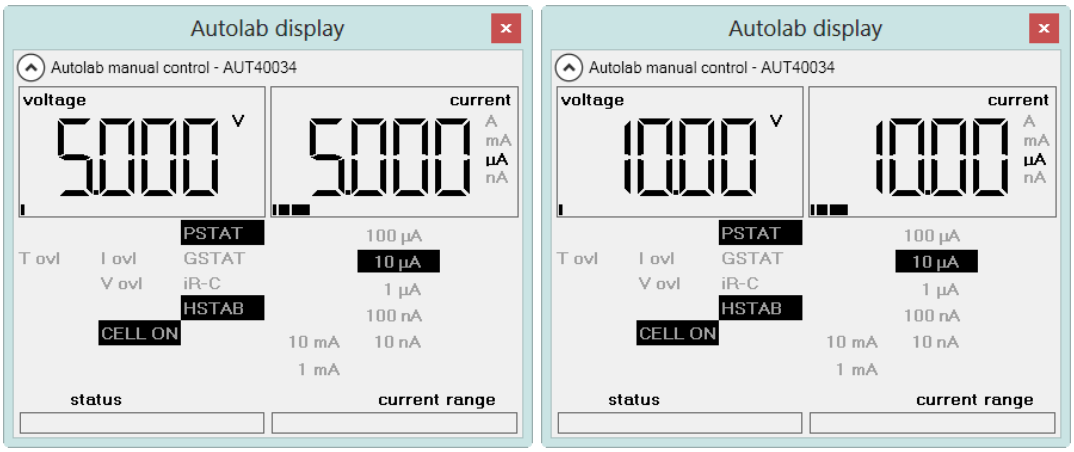

Figure 21 – The potential range depends on the value of the offset DAC (left – Offset value: 0 V, right – Offset value: 5 V)

During measurements, NOVA will also automatically adjust the offset DAC value is order to reach the required potential or current values. If the specified range for the scanning DAC is larger than 10 V (± 5 V) within a single measurement command, an error will be displayed during validation (see Figure 22).

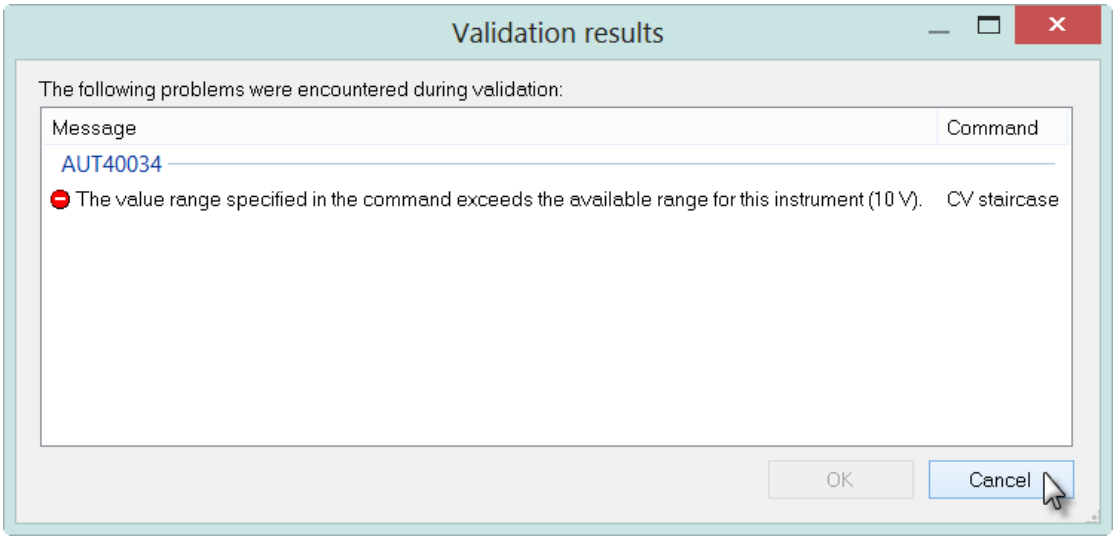

Figure 22 – An error is displayed when the specified value range is larger than 10 V for a single command

NOVA can adjust the offset DAC during a measurement, if needed, in between different measurement commands. However, the offset DAC should not be modified when the cell is on during a measurement. A warning is provided during validation if the procedure requires the offset DAC to be reset during the experiment (see Figure 23).

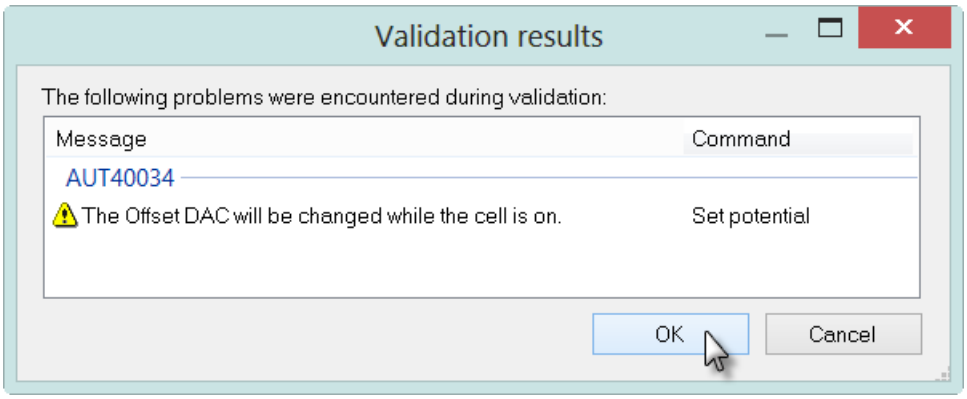

Figure 23 – A warning is provided when the offset DAC is reset while the cell is switched on

If the cell is not switched off when the offset value is modified, the potential applied to the cell will not be properly controlled (as shown in Figure 24).

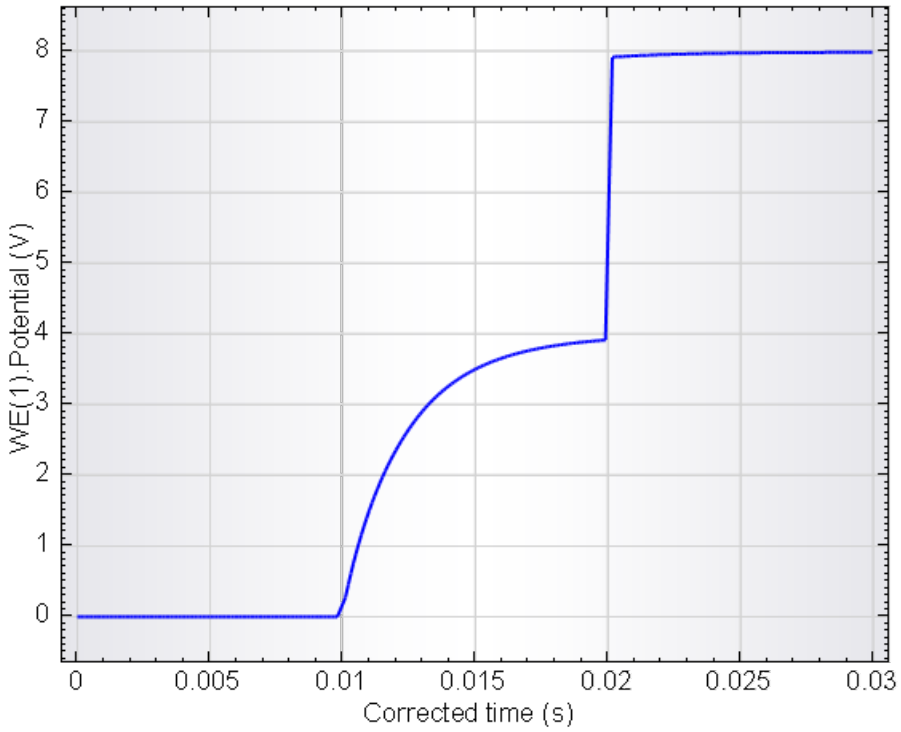

Figure 24 – Detail of the potential profile of a potential adjustment from 0 to 8 V in two steps (the first step, starting at 0.01 s corresponds to the setting of the offset DAC, the second step, at 0.02 s corresponds to the setting of the scanning DAC)

Figure 24 shows how the potential is adjusted, from 0 V to 8 V in the Autolab when both the offset DAC and the scanning DAC are modified in the procedure, with the cell switched on. The setting of the DACs has been intentionally delayed in this example to show the slower settling of the offset DAC compared to the scanning DAC.

This slow response of the offset DAC, combined with the fact that the software is not able to set both DACs at the same time means that there will always be an

uncontrolled potential profile between two consecutive potential values when the offset DAC needs to be adjusted. Consequently, an unexpected current response could be observed (see Figure 25).

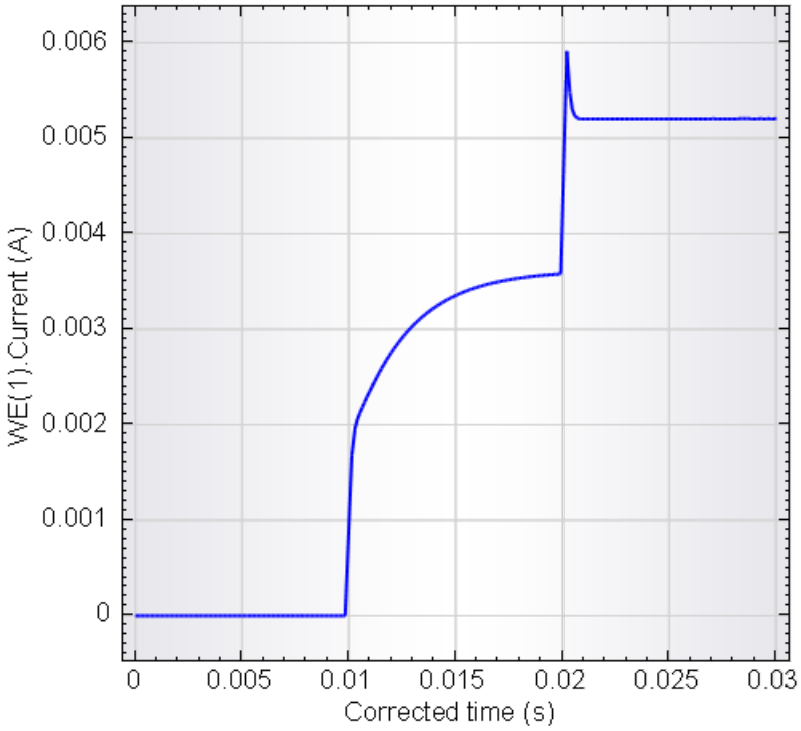

Figure 25 – Current response corresponding to the potential profile shown in Figure 24 measured on dummy cell (c)

This restriction only applies to measurement commands that require the offset DAC to be adjusted.

It is therefore highly recommended to switch the cell **off** whenever the offset DAC needs to be adjusted in an electrochemical measurement.

The value of the offset DAC can be defined manually in the Autolab control, using the Set Offset potential property (see Figure 26).

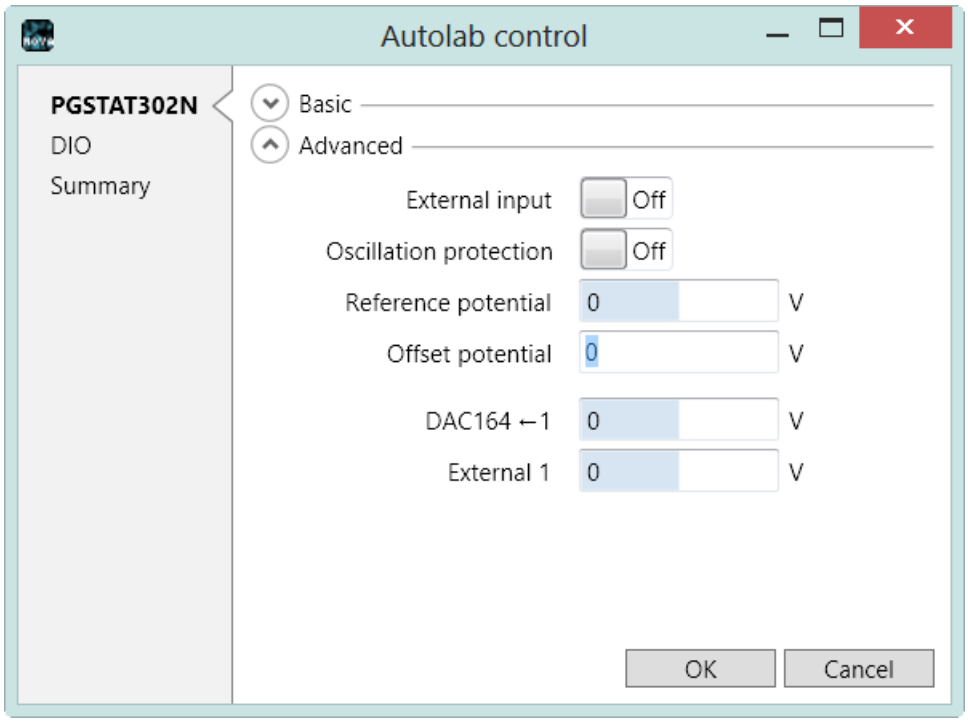

Figure 26 – The Autolab control command is used to define the Offset value

The Offset value can be set to any value between -5 and 5. Once the value of the offset DAC has been defined using the Autolab control, any voltage between (-5 V + Offset value) and (5 V + Offset value) can be defined using commands like: Set potential, CV staircase, etc.