

# NOVA

## Multi BA Tutorial



## 1 – The Multiple working electrodes (MultiBA instruments)

The MultiBA instruments are developed for special applications in which more than one working electrode is used in a single electrochemical cell. When a single BA module is used, the Autolab PGSTAT can be used as a bipotentiostat for applications like the Rotating Ring Disc Electrode (RRDE) measurements. The Bipotentiostat tutorial covers the use of a single BA module<sup>1</sup>.

When more than one additional working electrode is required, a special Autolab PGSTAT instrument can be used. This special instrument is referred to as a MultiBA and up to five identical BA modules<sup>2</sup> can be fitted inside this device. These BA modules are numbered 1 to 5 and they provide the control for additional working electrodes, numbered WE(2) to WE(6), respectively.

Each BA module is labelled as BA-MCX, where X is the index of the working electrode provided by the BA module (2 – 6). Figure 1 shows the front panel label of the first BA module in a MultiBA instrument.

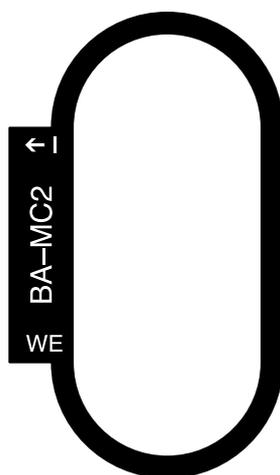


Figure 1 – Front panel labels for the MultiBA instruments (BA-MC2 shown)

The BA modules used in a MultiBA configuration are fitted with an extra BNC connector on the front panel. The top BNC connector, labelled  $\leftarrow I$ , carries the  $i_{out}$  signal from the BA current-to-voltage converter. The bottom BNC connector, labelled **WE**, is used to connect the working electrode cable, shown in Figure 2.

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<sup>1</sup> The Bipotentiostat tutorial also covers the use of the BIPOT and the ARRAY modules.

<sup>2</sup> It is not possible to install more than one BA module in a standard PGSTAT. The MultiBA systems are special models of the Autolab PGSTAT. The BA modules used in MultiBA instrument are not compatible with standard PGSTATs and vice-versa. Please contact your Autolab distributor for more information.



Figure 2 – The WEX cable used in a MultiBA (WE2 cable shown)

Regardless of the number of BA modules inside a MultiBA instrument, the additional working electrodes must be placed in the same cell as the main working electrode, WE(1). The additional working electrodes share the counter electrode and the reference electrode with the main working electrode.

In a MultiBA system, each BA module can be used to control the potential of its electrode relative to the common reference electrode (Bipotentiostat mode) or relative to the first working electrode (Scanning bipotentiostat mode). The electrochemical signal provided by the additional working electrodes, WE(X).Current and WE(X).Potential, can be selected in the sampler<sup>3</sup>.



### Warning

For more information on the BA module, please refer to the Bipotentiostat tutorial. The MultiArray instruments, using the DAC168, are not supported in NOVA and this tutorial only applies to MultiBA devices.

<sup>3</sup> In the rest of this tutorial, the additional working electrodes provided by the BA modules will be referred to as WE(X), with X being a value from 2 to 6. If a specific WE is identified in the tutorial, X will be replaced by the corresponding identifying number.

## 2 – Using the MultiBA

The MultiBA systems are characterized by two hardware settings: the **main module** and the **number of BA modules**. MultiBA systems can be used in combination with the following main modules: PGSTAT12, PGSTAT128N, PGSTAT30, PGSTAT302 and PGSTAT302N. Up to five BA modules can be installed in a MultiBA instrument.

The main module and the number of BA modules installed are defined in the hardware setup (see Figure 3). The BA modules are identified by a number, indicated next to each BA entry in the Additional Module(s) frame.

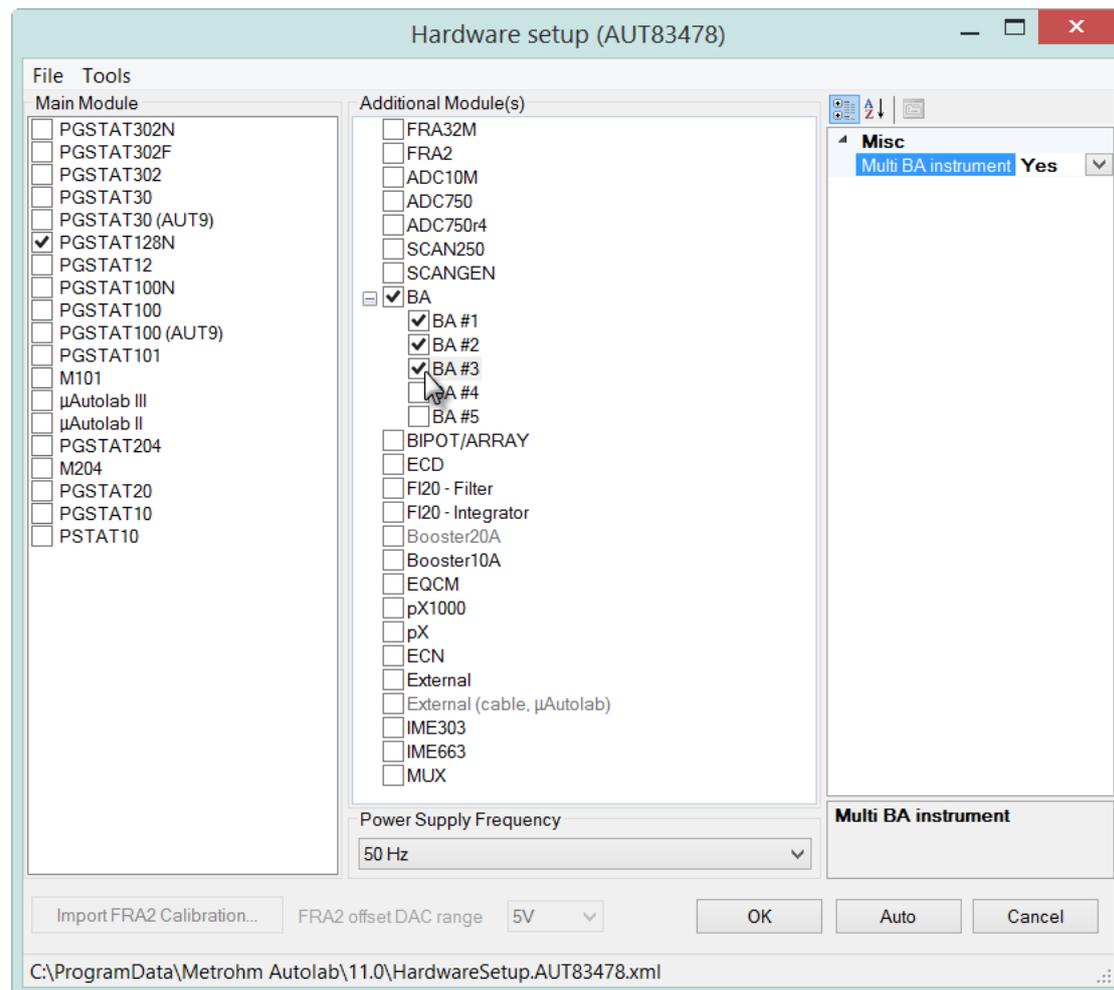


Figure 3 – Selecting multiple BA modules for a MultiBA instrument

The BA modules are automatically detected when a MultiBA system is connected to the computer for the first time. The number of BA modules in the instrument and the main module are automatically adjusted during the initialization of the instrument. No further hardware adjustments are required, unless the FRA2 or FRA32M module is also installed in the MultiBA device.



### Warning

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MultiBA instruments are special models of the Autolab PGSTAT. It is not possible to install more than one BA module in a normal Autolab PGSTAT. The MultiBA instruments cannot be fitted with additional modules, with the exception of the FRA32M or FRA2 module.

- For PGSTAT12, 128N (serial number < AUT83730) 30, 302 and 302N (serial number < AUT83680), the maximum number of BA modules is 5 without a FRA32M/FRA2 module and 3 in combination with a FRA32M/FRA2 module.
- For PGSTAT128N (serial number AUT83730 and higher) and PGSTAT302N (serial number AUT83680 and higher), the maximum number of BA modules is 5, with or without the additional FRA32M/FRA2 module.



### Warning

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Make sure that the **Multi BA instrument** configuration property, shown in the frame on the right-hand side of the Hardware setup window, is set to Yes for **all** the BA modules (see Figure 3).

## 3 – Using the BA module in a MultiBA system

The additional working electrodes, WE(X) provided by the BA modules do not require dedicated measurement commands. This means that the BA modules can be used with any measurement command which uses the sampler (CV staircase, LSV staircase, Chrono methods...).



### Note

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The BA modules can only work in potentiostatic mode. The main potentiostat can be set to galvanostatic mode. In BIPOT mode the potential of the second working electrode will be defined with respect to the reference electrode. In Scanning BIPOT mode, the potential of the second working electrode will be defined with respect to the first working electrode.

Depending on the specified hardware configuration, the WE(X).Current, WE(X).Charge and WE(X).Potential signals will become available in the signal sampler (see Figure 4).

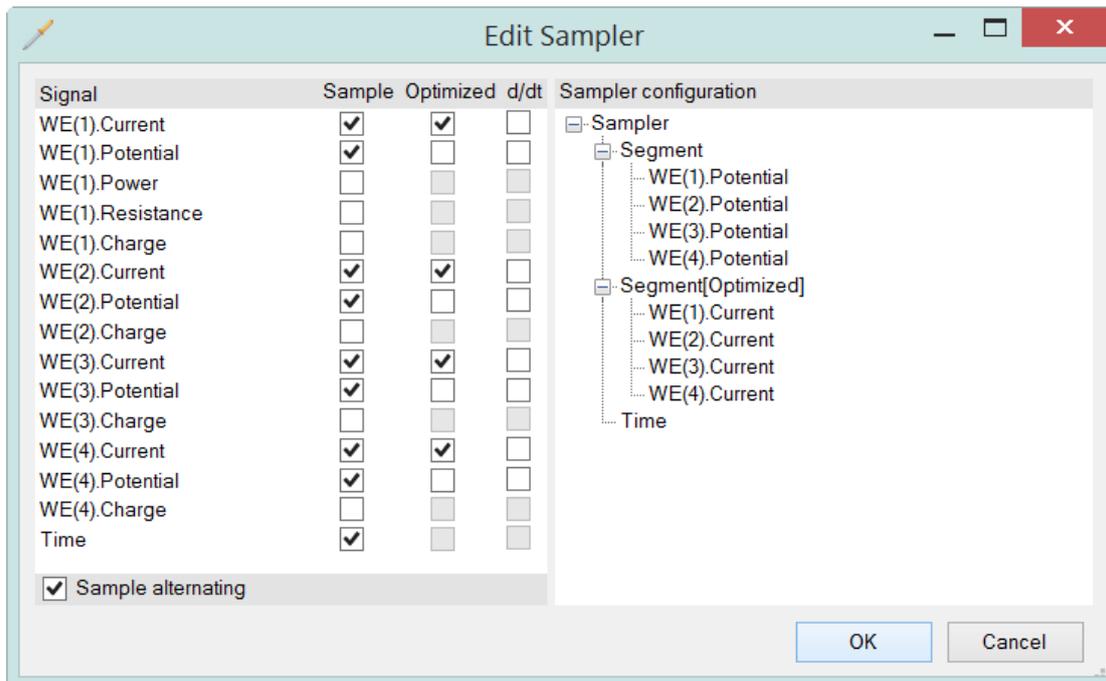


Figure 4 – The WE(X).Current, WE(X).Potential and WE(X).Charge signals are available in the signal sampler

The WE(X).Current, WE(X).Potential and WE(X).Charge signals can be sampled during the electrochemical experiment in the same way as the other available signals.



#### Note

The maximum number of Optimized signals that can be sampled in any experiment is **six**.



#### Note

The WE(X).Potential signals available for the BA modules depend on the settings of each of the modules. When the BA module is set to Bipotentiostat mode (BIPOT), the WE(X).Potential value is equal to  $E_{Ref} - E_{WE(X)}$ . When the BA module is set to scanning bipotentiostat mode (Scanning BIPOT), the WE(X).Potential value is equal to  $E_{WE(1)} - E_{WE(X)}$ .

## 4 – Automatic current ranging

Independent Automatic Current Ranging (ACR) options can be defined for each working electrode in the MultiBA configuration.

Clicking the Options button in the procedure editor frame displays the Edit options window. Depending on the number of BA modules specified in the hardware setup, several working electrodes will be listed in the Automatic current ranging tab (see Figure 5).

The example shown in Figure 5 corresponds to the hardware setup shown in Figure 4. The ACR option is used for WE(1), WE(2) and WE(4). This option is not used for WE(3).

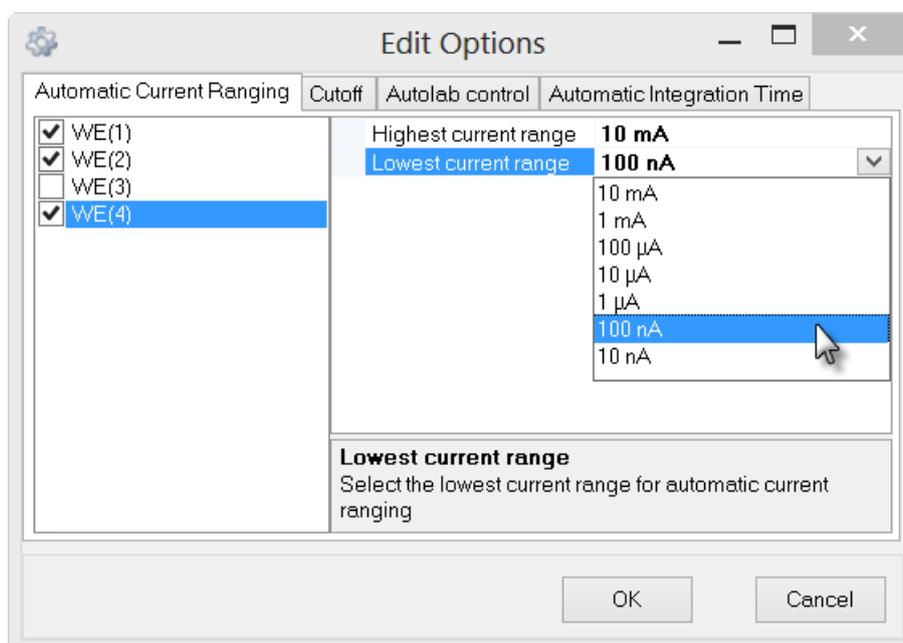


Figure 5 – The automatic current ranging settings for WE(X)

## 5 – WE(X) electrode settings

All the settings of the available WE(X) can be defined using the *Autolab control* command (see Figure 6). The settings for each WE are listed in BA section of the Autolab control window. Only the electrodes specified in the hardware setup are listed in the Autolab control window (see Figure 6).

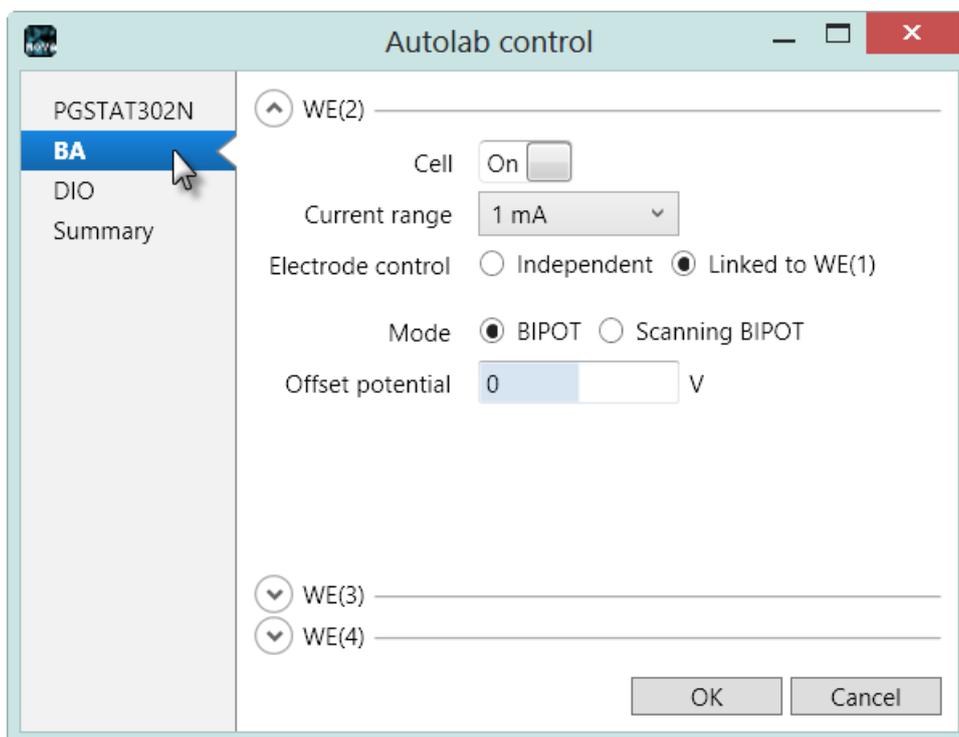


Figure 6 – The WE(X) properties are set in the Autolab control command



### Note

The properties of WE(2) are displayed by default. Click the  button located next to the other WE(X) shown in the Autolab control window to display the properties of the additional working electrodes.

Five settings are available with the **BA** modules [WE(2-6)]:

- **Cell:** used to set the cell switch for WE(X) on and off.
- **Current Range:** used to select the current range of WE(X).
- **Electrode control (independent, linked to WE(1)):** defines the relationship between the cell switch of WE(X) and WE(1). When this setting is set to *Linked to WE(1)*, the cell switch of WE(X) will automatically be set to the same status of the cell switch of WE(1). Using the *Set cell* command, these cell switches will be toggled at the same time. When this setting is set to *Independent*, the cell switch of WE(X) is decoupled from the cell switch of

WE(1). To switch the cell on for WE(X), the Cell on/off toggle available in the Autolab control window must be used.

- **BA Mode:** defines the mode for WE(X) (BIPOT/Scanning BIPOT).
- **Offset potential:** defines the potential difference between WE(X) and the reference electrode in BIPOT mode and between WE(X) and WE(1) in Scanning BIPOT mode.



#### Note

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The default startup Electrode control setting for all working electrodes is: linked to WE(1).



#### Warning

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When the *electrode control* is set to *independent*, a specific order must be respected to avoid current leakage between WE(1) and WE(X). Always set the cell of WE(X) to ON **after** the cell has been set to ON for WE(1). Always set the cell of WE(X) to OFF **before** the cell has been set to OFF for WE(1).



#### Note

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The *Set cell OFF* command switches the cells switch for all working electrodes automatically, regardless of the *Electrode control* setting defined in the Autolab control window.

To define the settings for WE(X), select the required item from the drop-down lists displayed in the Autolab control window. For example, to set the WE(2) mode, select the BIPOT or Scanning BIPOT using the provided radio buttons (see Figure 7).

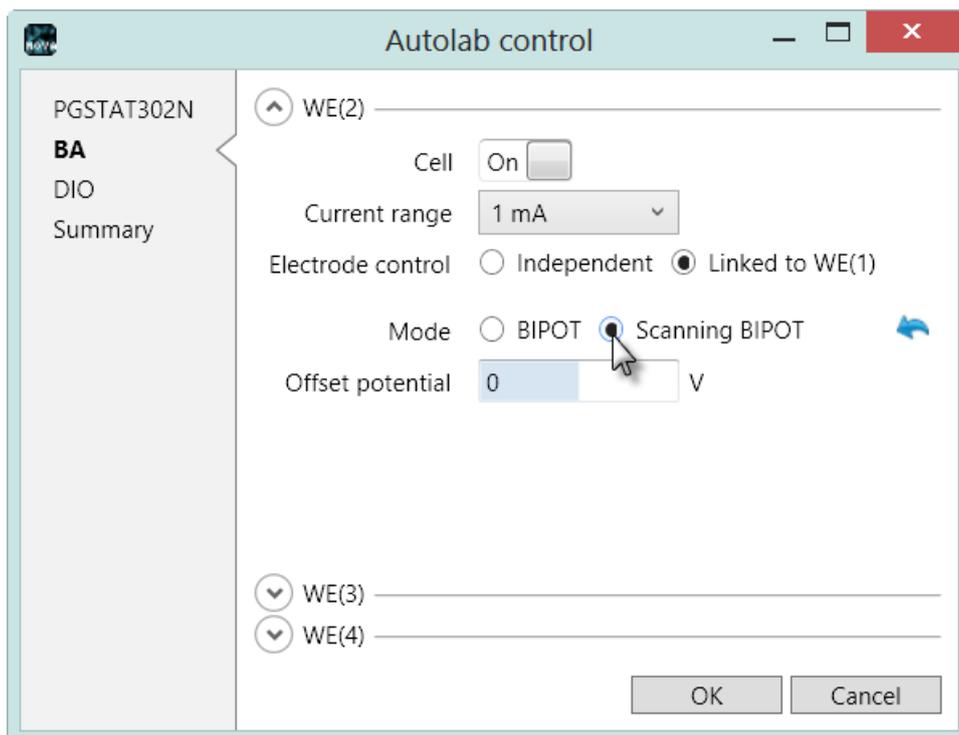


Figure 7 – Setting the mode for the second working electrode

To set the potential of the WE(X), relative to the reference electrode or the first working electrode, change the Offset potential value using the provided input field in the Autolab control window (see Figure 8).

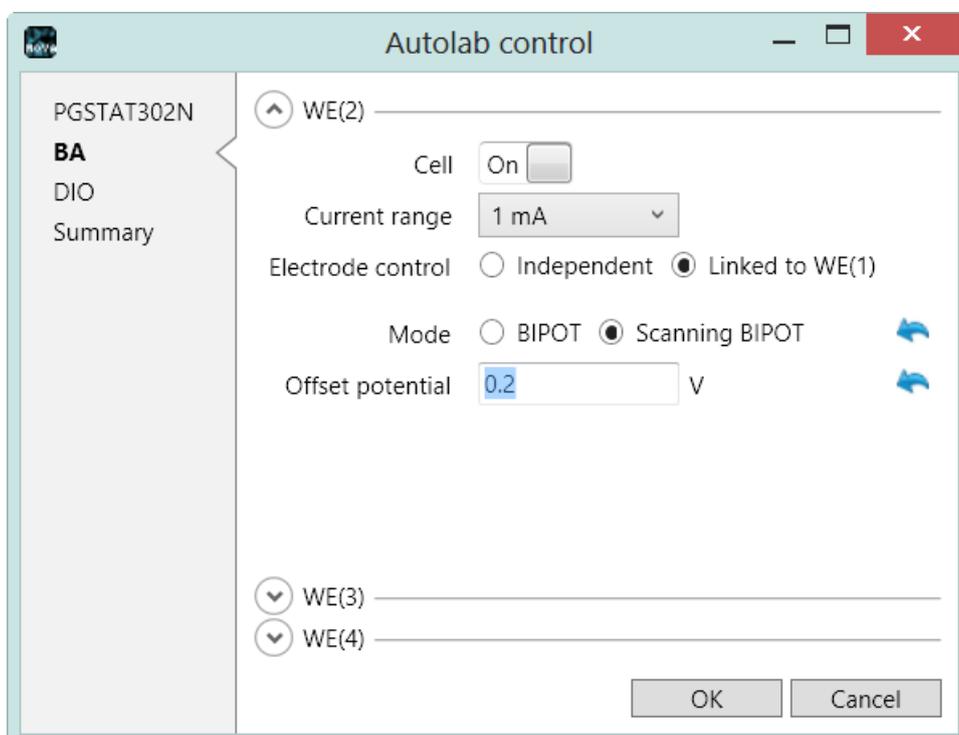


Figure 8 – Setting the potential of the WE(X)

## 6 – Possible measurements

All the electrochemical techniques supported in NOVA are possible with the MultiBA instruments, with the exception of those requiring a dedicated module. Impedance measurements are possible if a FRA2 or FRA32M module is installed in the MultiBA instrument, however it is only possible to perform electrochemical impedance spectroscopy measurements using WE(1).



### Note

The BA modules can only work in potentiostatic mode. The main potentiostat can be set to galvanostatic mode. In BIPOT mode the potential of the second working electrode will be defined with respect to the reference electrode. In Scanning BIPOT mode, the potential of the second working electrode will be defined with respect to the first working electrode.