FRA Interface

Besides the impedance measuring capabilities of the electrochemical workstations IM6/IM6eX themselves, the workstations offer the feature to acquire the frequency response of EXternal Devices (EXD) by its Frequency Response Analyser (FRA) module.

The FRA module interfaces third-party potentiostats and electronic loads to the IM6/6eX system. The EXD must provide an analogue control input and analogue signal outputs for the measured current and voltage. FRA is fully supported by the Thales software. Only the gain factors have to be set for each EXD individually.

The control signal provides both, the DC signal controlling the DC current or voltage of the EXD and the AC signal necessary e.g. for EIS measurements.

Technical specifications

Control output	+-10 V (DC + AC)
Current input	+-10 V
Voltage input	+-10 V
frequency response	0 – 1 MHz
Inputs & outputs	differential in/out
Gain factors	by software

Installation of the FRA interface (hardware)

FRA is consisting of two small boxes which are connected to the *Probe E* and *Probe I* connectors of the IM6/6eX. Make sure that nothing is connected to the BNC inputs of the IM6/6eX at the same time. This will yield erroneous measurement data.

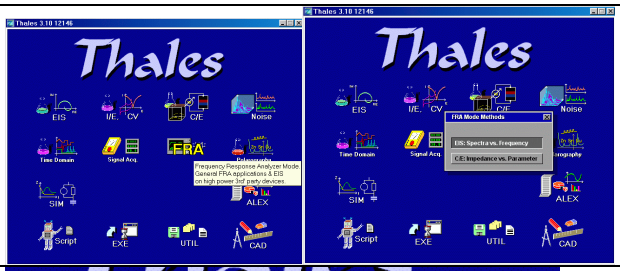
Connect the *Probe E* cable of the FRA to the *Probe E* input of the IM6/6eX.
Connect the *Probe I* cable of the FRA to the *Probe I* input of the IM6/6eX.
Connect the *Signal Out* of the FRA to the analogue control input of the EXD.
Connect the *Current In* of the FRA to the analogue current output of the EXD.
Connect the *Voltage In* of the FRA to the analogue voltage output of the EXD.

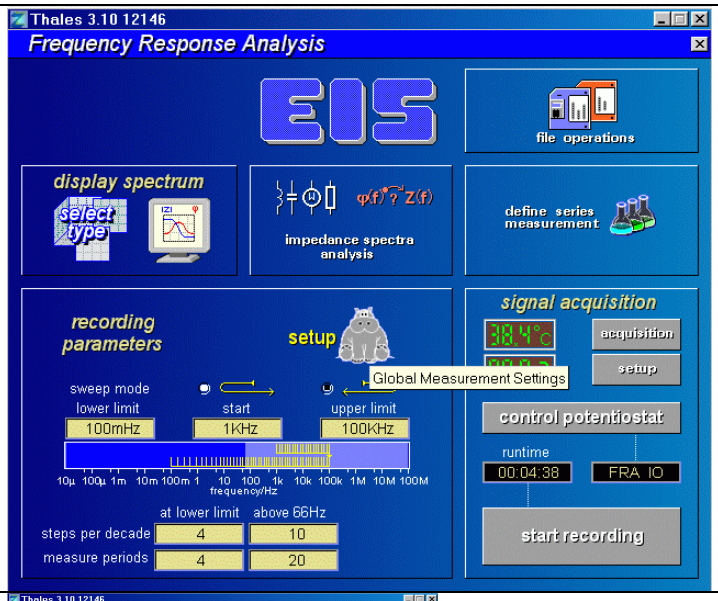
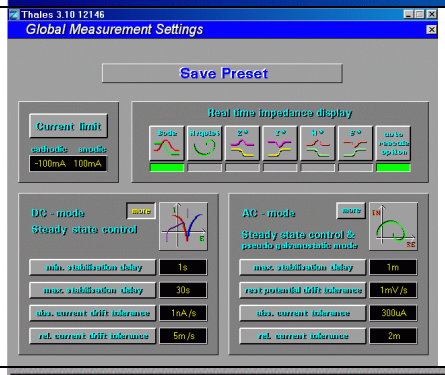
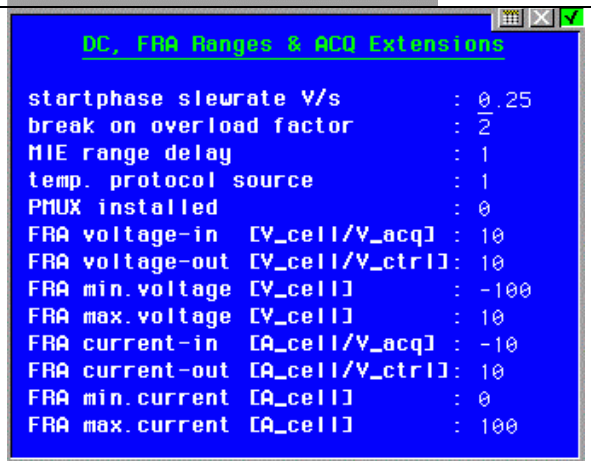
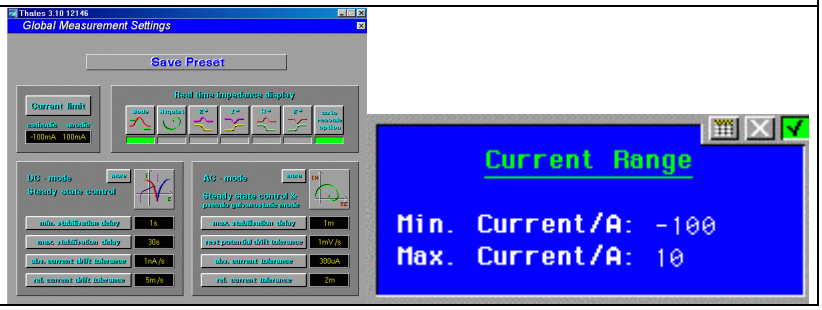
The FRA provides an input as well as an output range of +-10 V. These ranges are fixed. The scaling factors for both, signal inputs and control output, are set in the *AC More* box:

Setting up of the FRA gain factors (software)

Before setting up the gain factors, the FRA interface must be disconnected from the IM6/IM6eX potentiostat connectors to avoid a damage of the connected cell.

To set the gain factors of the EXD starting from the Thales main menu, please proceed as follows:

1.) Go to FRA and from the appearing sub menu 'FRA mode methods' select the item: 'EIS: spectra vs. Frequency'	
2.) The software displays a warning that you have to disconnect your cell At the latest now, you have to disconnect the cell and click the 'yes'- button to continue	

3.) Immediately, you enter the FRA menu, where you have to select the ‘setup’-button by clicking on the ‘hippo pictogramme’	
4.) You are entering the ‘Global measurement setting’ – submenu where you have to select the DC – mode settings, clicking on the ‘more’-button.	
5.) Finally, a box is displayed where you have to set the individual gain factors for the FRA mode An example for the corresponding values you have to insert into the box is given below. In this example, an electronic load of Zahner – the EL300 – is handled as an EXD.	
6.) Finally, you have to set the current- limits (min and max) in the settings.	

Entry	Value	Meaning
FRA voltage in [V_cell/V_acq]	10	The cell voltage [V_cell] is the measured voltage [V_acq], acquired by the IM6, multiplied by the gain factor given here (10), i. e. V_cell = Vacq * value
FRA voltage out [V_cell/V_ctrl]	10	The cell voltage [V_cell] is the settled voltage [V_ctrl], set by the IM6, multiplied by the gain factor given here (10), i.e. V_cell = V_ctrl * value
FRA min voltage [V_cell]	-100	Minimum voltage, the EXD can supply
FRA max voltage [V_cell]	10(1)	Maximum voltage, the EXD can supply
FRA current in [A_cell/V_acq]	-10	The current through the cell [A_cell] is the product from the measured voltage [V_acq] - acquired by the IM6 and the gain factor given here (-10), i.e. A_cell = V_acq * value
FRA current out [A_cell/V_ctrl]	10	The settled current through the cell [A_cell] is the product from the control- voltage [V_ctrl] (set by the IM6) and the gain factor given here (-10), i.e. A_cell = V_ctrl * value
FRA min current [A_cell]	0	Minimum current, the EXD can supply
FRA max current [A_cell]	100	Maximum current, the EXD can supply

(1) The Thales software handles minimum and maximum values of the EXD very strict. For safety purposes, the Thales software will stop a FRA experiment immediately, provided one of these limits is violated solely for a single data point of the measurement.
Therefore it is useful to select a slightly 'higher' value for the extremes to avoid the interrupt of the experiment.
For instance, the electronic load EL 300 can take out up to –100 A from a battery or a fuel cell or similar objects. If you want to perform an experiment where you decrease the current from –100 A to 0 A in particular steps, the measured voltage may become slightly positive due to internal offsets (in the mV or µV range), setting a current of 0 A. Therefore the maximum value for V_cell is set to '(+)10' whereas practically, the EXD can supply only negative values.

For further information refer to ***THALES*** manual **EIS 5.3**.