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Introduction

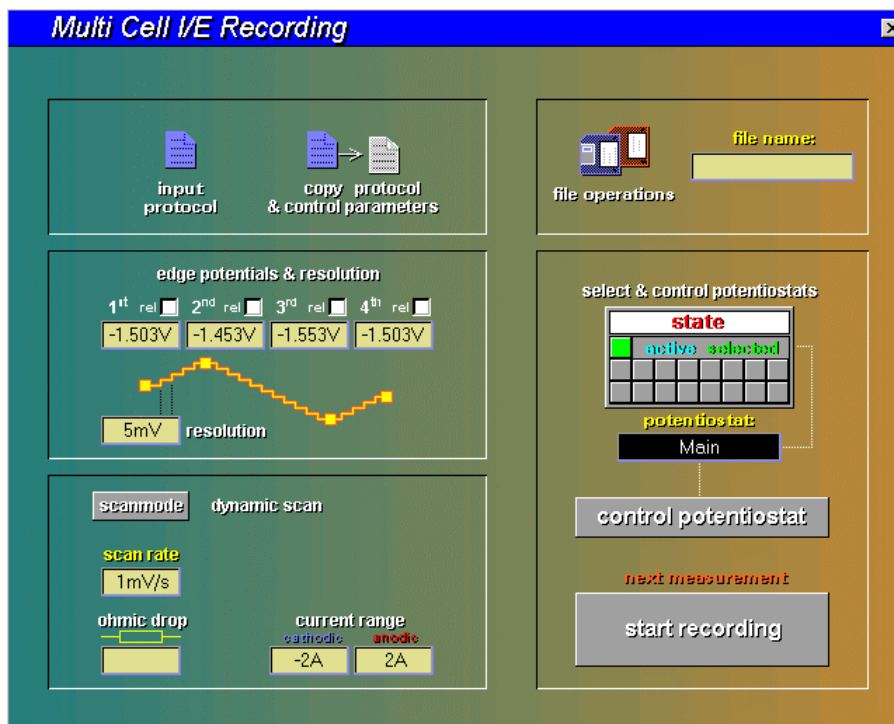
The special software multi cell I/E is an extension of the I/E standard program. The multi cell mode is able to operate up to eight auxiliary potentiostats of the EPOT01 model or something like that. Operation can be effected in groups of four potentiostats at maximum. The measurement data acquisition as well as the output of the control parameters take place in a parallel process for all activated potentiostats.

Some restrictions regarding mode and control parameters have to be accepted although multi cell I/E is very similar to the standard program. It was the restrictions which made a parallel treatment of the auxiliary potentiostats possible. The mode must be set to dynamic scan, as Ohmic losses will not be offset.

In the following, multi cell I/E will be abbreviated by MC I/E.

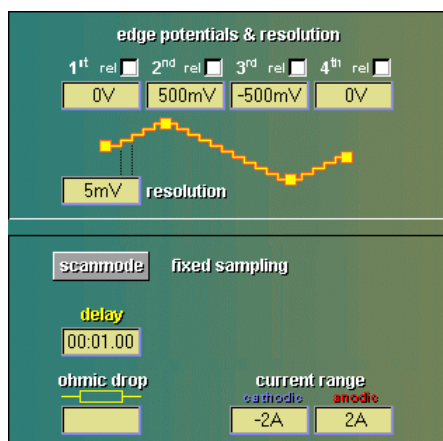
1. Multi Cell I/E Main Menu

MC I/E starts up with the graphical menu shown below. The installed submenus can be called up by activation of the corresponding button.



The submenus can easily be recognized through their titles and symbols which are plotted within the button. The main menu manages various submenus, which will be described briefly.

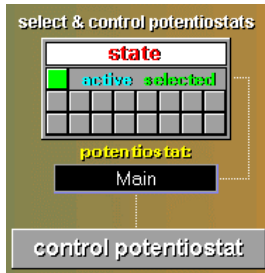
1.1 Edit Parameters



setting of control parameters

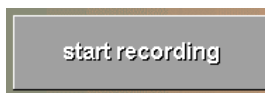
- edge potentials
- scan rate
- resolution
- scan mode
- tolerances
- delay times
- current limiting

1.2 Select & Control Potentiostats



select and display potentiostats or calls up submenu 'test sampling' of the impedance measurement program EIS

1.3 Start Recording



starts next measurement

1.4 File Operations



disc i/o operations of I/E data (save and load measurement, select i/o device and data path)

1.5 Input Protocol



input cell protocol

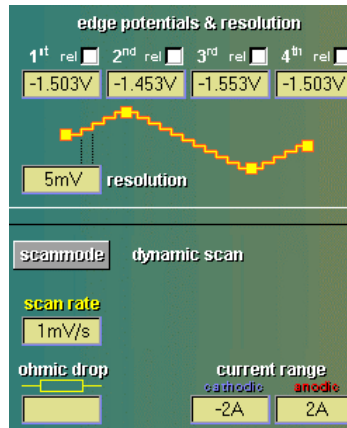
1.6 Copy Protocol & Control Parameters



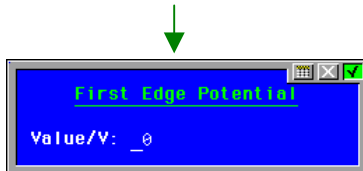
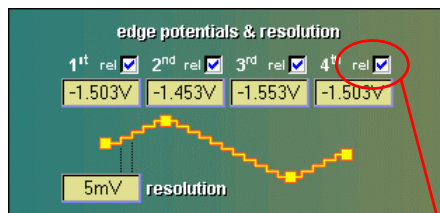
copy control parameters and protocol

2. Edit Parameters

The actual control parameters and the selected scan mode are indicated in the main menu within two boxes.



2.1 Edge Potentials



Four edge potentials can be defined independent from each other, wherever two successive potentials define a ramp. These potentials can be changed by activating the corresponding button and inputting the new value. The edge potentials can be defined in two ways:

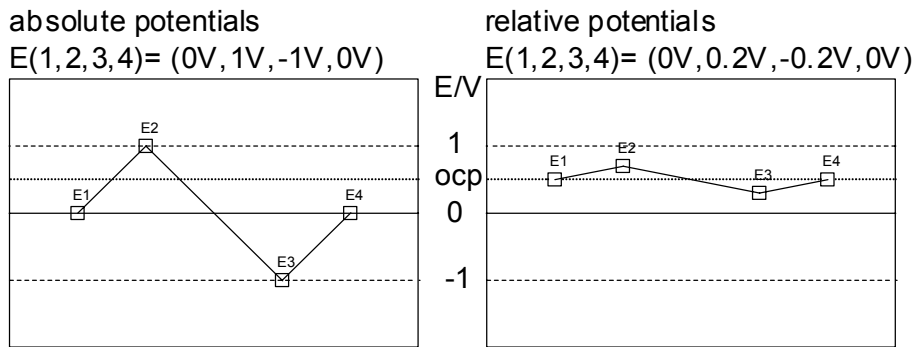
- a) absolute potentials reference $E_o=0V$
- b) relative potentials reference $E_o=OC$ (open circuit potential)

The selected mode is indicated by a blue tick within the checkbox. It can also be indicated during input by means of appending the corresponding abbreviation (rel) or (abs) to the actual value.

The relative mode function offers the possibility to investigate different probes in a defined potential range relative to the open circuit potential (ocp). The ocp is set to the actual value through a change to the submenu 'test sampling' of the EIS impedance measurement program. In addition, the potentiostat has to be switched off. There is no ocp control during an I/E recording.

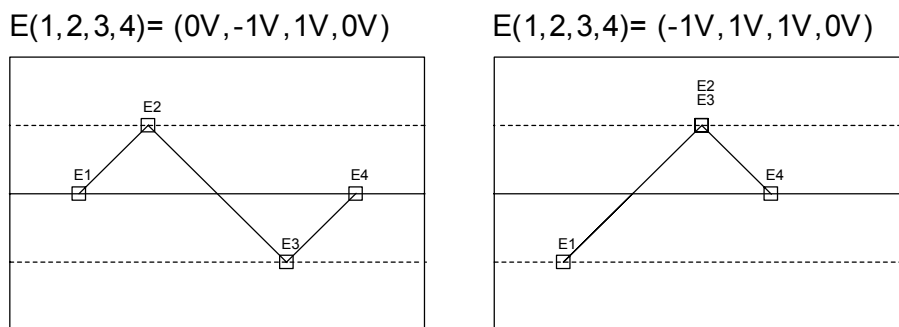
Relative and absolute potential settings can be mixed for any ramp. The setting of two successive edge potentials to the same value reduces the number of ramps and the shape of the control curve. It is possible to make a choice between bi-directional and mono-directional potential control.

Example: equivalent circuit ocp=.5V

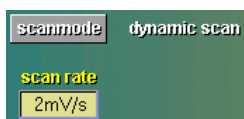


The output of relative and absolute potentials can be mixed. But one restriction has to be taken into account, namely that there will be no measurement of the rest potential during a running I/E measurement and changes in the system will not be considered, too. The rest potential is measured whenever the measure routine of the potential is put through in the program, for example, during the test sampling or the I/E starting phase with the potentiostat being deactivated. If two succeeding potentials get the same value, this ramp will not be carried out. By doing this, the shape of the control curve can be changed to measure something like mono-directional or bi-directional curves.

Example of curve shapes:

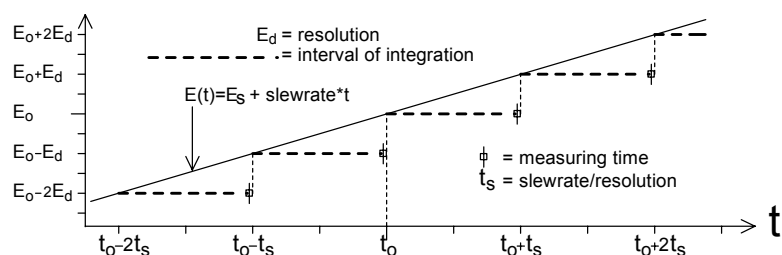


2.2 Scan Mode

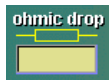


Dynamic scan is the only mode which is able to carry out MT I/E measurements. Other available modes can solely be applied with single I/E measurements.

Like a CV measurement the dynamic scan mode works with lower increase speed of the voltage (slew rate=sr): $10\mu\text{V/s} \leq \text{sr} \leq 10\text{mV/s}$. Slew rate and resolution represent the control parameters of the dynamic scan. Ramps come out with set slew rate, measured data is acquired during equidistant steps of potentials (resolution).



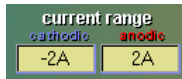
2.3 General Parameters



Ohmic drop is not compensated in the multitasking I/E program.

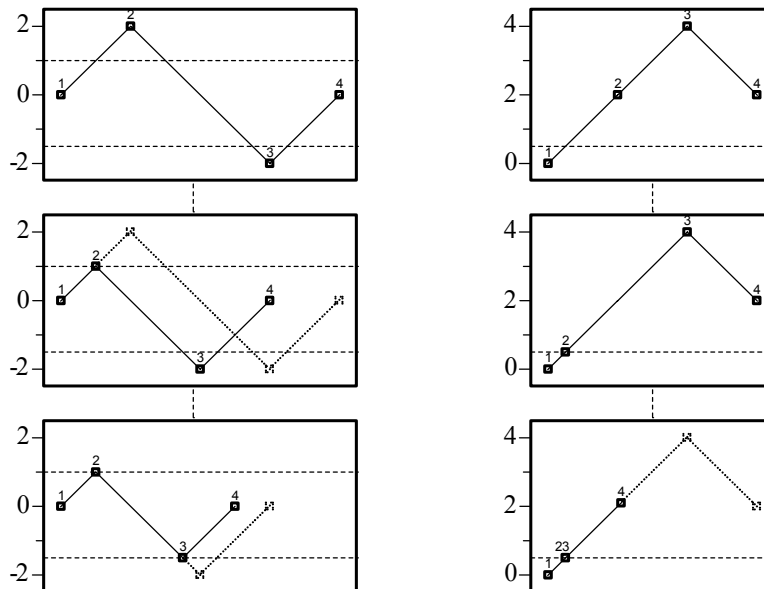


'Resolution' defines the step width of the potential in the modes steady state and fixed sampling. The dynamic mode resolution defines the step width of the measured I/E data.

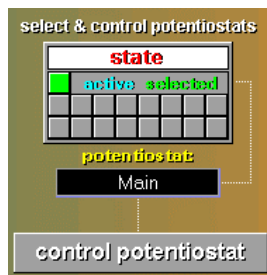


The hardware limits the current in order to protect the electronics regarding the applied laboratory resistor. For certain systems only limited current ranges are allowed.

The anodic as well as the cathodic current range can be selected independently. The exceeding of one of the limits would cause the actual ramp to be interrupted and the corresponding end potential to be corrected. Finally, the next ramp will be started with respect to the corrected edge potentials.

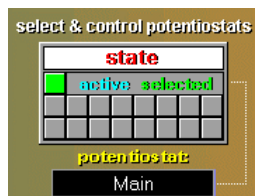


3. Select & Control Potentiostats



3.1 Activation of Potentiostats

After the MC I/E software has been started, only the main potentiostat of the *Zennium* is activated for the time being, whereas the auxiliary potentiostats remain disabled. The chosen potentiostat as well as the valid status at the moment are shown in the window status.



The main potentiostat has been switched to 'active'(i.e. green square). The panel of two times eight gray switches is used for the selection of the auxiliary potentiostats. The switches are numbered consecutively all the way through from the upper left to the upper right. The first number is one.

An auxiliary potentiostat is activated by pressing the corresponding switch. If a device has inadvertently not been connected, a warning will occur. The activated potentiostat is now shown by the green colour of the corresponding button. Devices which have been picked up once will remain installed in the background and the corresponding response button turns blue. In order to delete an auxiliary potentiostat in the list, this potentiostat has to be selected by pressing the corresponding blue button. Further pressing of the green button deactivates the potentiostat and the button turns gray again.

! **ATTENTION:** If a change between potentiostats take place, the potentiostat which has been picked up last will be 'frozen' in its momentary condition. Turned on potentiostats remain switched on after the transfer to an other device. Auxiliary potentiostats, too, should, for example, be switched off during the changing of probes.

3.2 Control Potentiostats



The subordinate program test sampling of the EIS impedance measurement program can be reached via the control potentiostat function (see *Thales* manual). Test sampling turns the potentiostat on or off. Each potentiostat should be switched on before the beginning of a MC I/E measurement whenever the absolute potentials are given already. There is no automatic 'start up ramp' for this mode in the MC I/E.

VOLTAGE POTENTIostat ON
 GALVANostat OFF

DC VOLTAGE
0.104 V

DC CURRENT
0 A

FREQUENCY	AMPLITUDE	COUNT
1KHz	0V	1

IMPEDANCE
Ω

PHASE
0

TESTSAMPLING & POTENTIostat CONTROL

DEVICE 0
Main

calibration ?

check cell connections

setup

AC display

- |Z|, φ
- Z', Z''
- Y', Y''
- R // C
- R - C
- R - L
- L, Q

AC VOLTAGE U

TIME

SPECTRUM U

ORDER

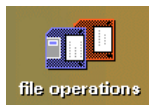
AC CURRENT I

TIME

SPECTRUM I

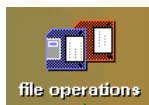
ORDER

4. File Operations

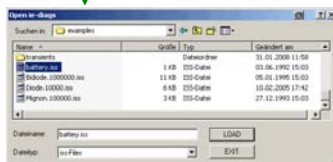


The 'display diagram' function will recall the last record. The measured data will be displayed on the screen.

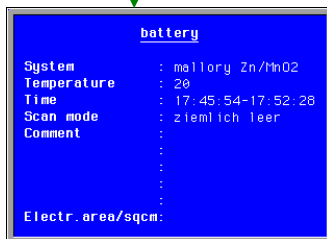
4.1 Open



This function allows you to load/save I/E data from/to the hard disk of your PC. Click on the icon and decide in the submenu, whether you want to open previously stored I/E data or save actual I/E data.



Select a path and a file and click on the **LOAD** button to load the file to the *Thales* software.



The next box shows the measurement parameters of the loaded data. Click on it if you want to close it.

NOTE: Opening a file will switch off the potentiostat and configures the potentiostat according to the loaded measurement-settings automatically. Loading a measurement file is an easy way to perform a new measurement with previously used settings.

4.2 Input Cell Protocol



The measurement protocol is entered. It consists of ten text lines. Measurement parameters and comments are stored in this bloc. Input is made either by the user or automatically by the program. External parameters which have not been measured by the *Zennium* system may be entered in the comment lines. After a measurement has been loaded the protocol is shown for control purposes.

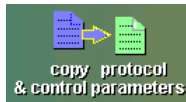


Should no changes be made, the relevant line will have to be confirmed with <RETURN>. With the <Pos1> or the <ESCAPE> button it is possible to return to the first line, for example, to correct input information. The editor is quit when the last line has been confirmed. The editor can be left by using the buttons <end> or <ESCAPE>.

line		input	content
system	: Na/HI2LO/FI2L	user	system description
temperature	: RT	user	system description
time	: 15:20:33-15:29:34	automatically	run time
scan mode	: 5mV/s	automatically	slew rate
comment	: An unexpected ex-	user	comment 1
	: plosion has been	user	comment 2
	: observed before	user	comment 3
	: the start.	user	comment 4
	:	user	comment 5
	: EPOT #3	automatically	number of the EPOT

The measurement protocol can be entered separately for each potentiostat. It can also be transmitted to all recognized EPC4 channels by means of the copy function.

4.3 Copy Protocol & Control Parameters



Here, the control data and the protocol of the potentiostat active at present are copied on all recognized measurement channels. So the protocol does not have to be entered newly for all potentiostats if the examined systems are equal.

5. Start Multi Cell Recording

Before the measurement is started all system parameters should have been entered and controlled. Wrong control parameters lead to the cancellation of a measurement. Also if the current is exceeded, for example, because of build-up transients, which occur when the potentiostat is switched on, it could happen that the relevant potentiostat is turned off.

Therefore the following procedure is recommended:

After the start of the program only the main potentiostat of the *Zennium* is activated. Now all additional potentiostats which are to be used and the corresponding parameters have to be chosen accordingly. The parameters of the potentials as well as of the slew rate and the run time respectively can be different. Should all devices be operated with the same corner data, the copy function will have to be used. Previous settings can be reconstructed by loading a measurement for the activated potentiostat.

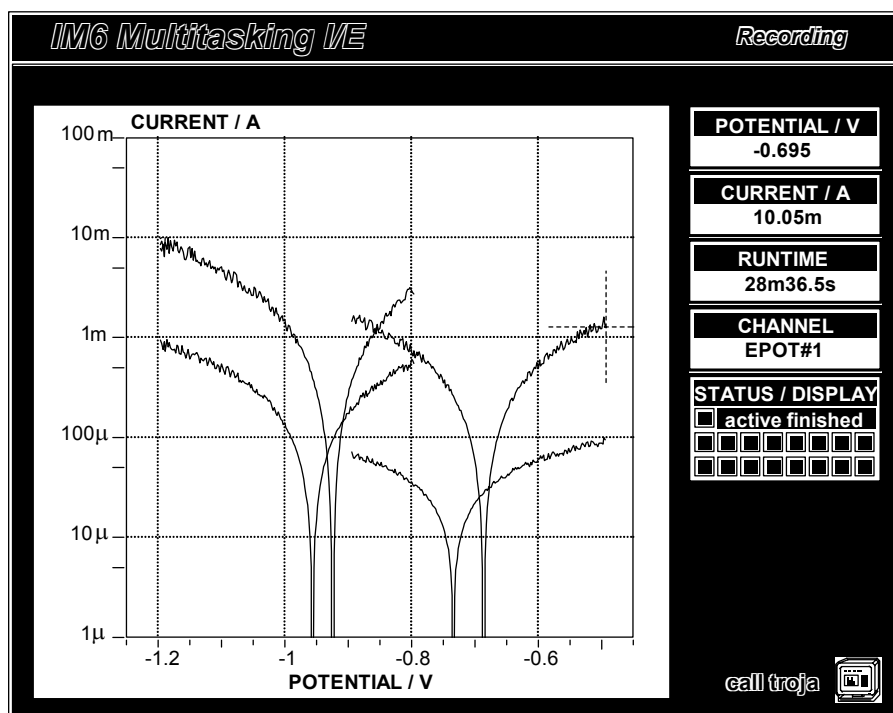


ATTENTION: If the absolute potential mode is required, each additional potentiostat in the start potential (1st corner potential) of the test sampling (control potentiostat) will have to be switched on. If the measurement is to be relative to the rest potential, all potentiostats will have to be turned off. It has also to be considered that the potentiostats remain in the condition in which they have been before the start of the measurement. Turned on potentiostats remain switched on after the measurement.

When all settings have been controlled, the next measurement is started via the function 'start recording'.

start recording

The measurement data is shown online in the 'recording' window.



Next to the graphical window there are four digital displays which present the following data:

POTENTIAL / V
-0.695

output potential

CURRENT / A
10.05m

measured current

RUNTIME
28m36.5s

run time

CHANNEL
EPOT#1

selected potentiostat

STATUS / DISPLAY
 active finished

There is a panel of buttons in the status window. The selected potentiostats are marked green, the potentiostats whose scan has been finished are indicated by red buttons. A crosshair marks the measuring curve of the potentiostat whose data is shown in displays at the moment. The potentiostats can be changed by pressing the corresponding button.

After the measurement the measurement data is saved and the end of the measurement is indicated.