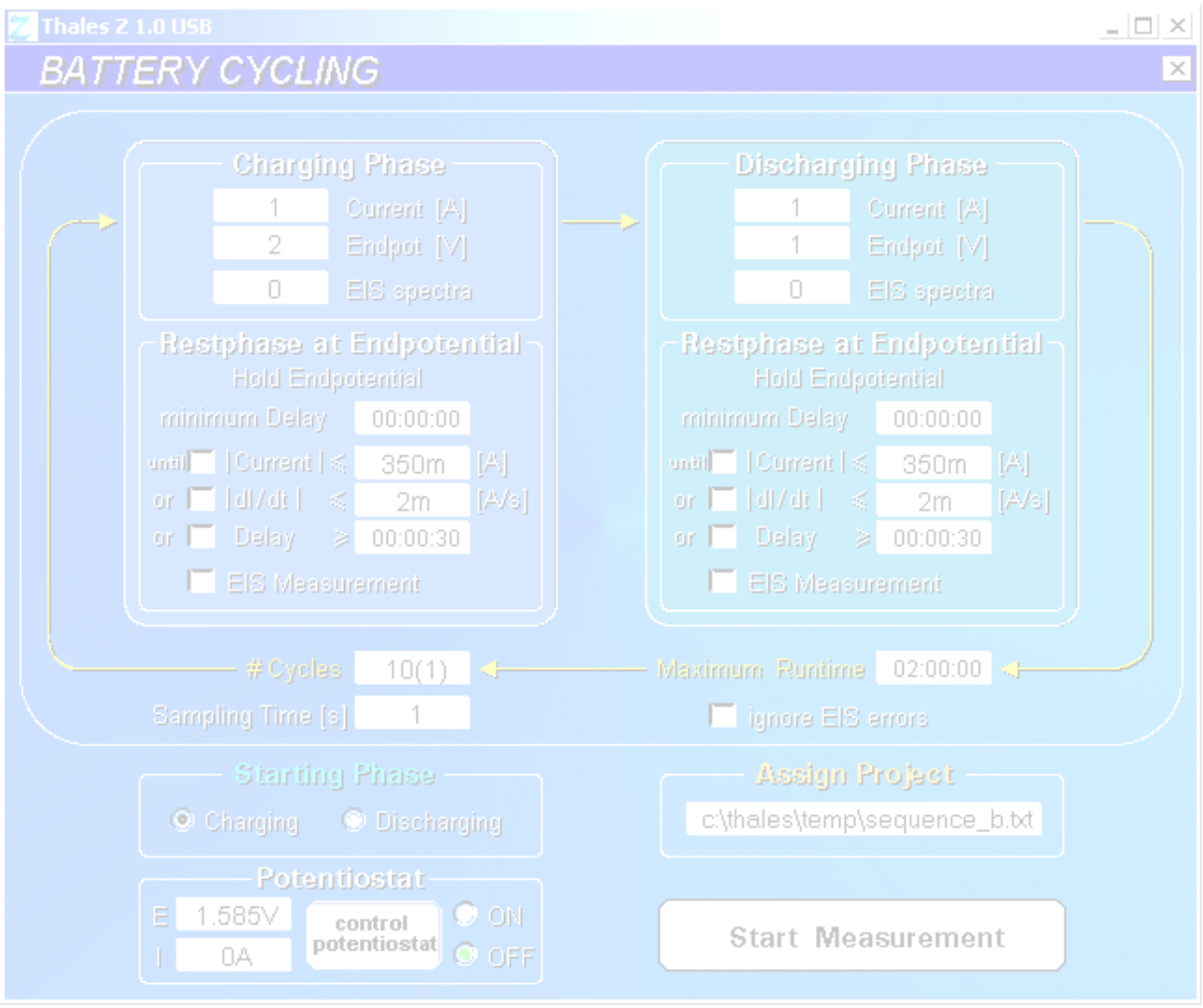
Battery Cycling

DC cycling script for battery applications with AC-EIS spectroscopy during ramps



1. General Information ____ 4

1.1 Resources and Paths ... 5
1.2 Generating the Runtime File ... 6
1.3 Starting BATTERY CYCLING by Use of EXE ... 7

2. BATTERY CYCLING Main Menu ____ 8

2.1 The BATTERY CYCLING Projects ... 9
2.1.1 Selection of Projects ... 9
2.2 File Descriptor Block ... 10
2.3 Description of Runtime Parameters ... 10
2.3.1 Charging Phase ... 10
2.3.2 Discharging Phase ... 11
2.3.3 Restphase ... 11
2.3.4 Count of Cycles, Runtime and Starting Phase ... 11
2.3.5 Sampling Time ... 12
2.3.6 Ignore EIS Errors ... 12

3. Next Measurement ____ 13

3.1 Start Measurement ... 13
3.2 Interrupt of a Running Cycling ... 14

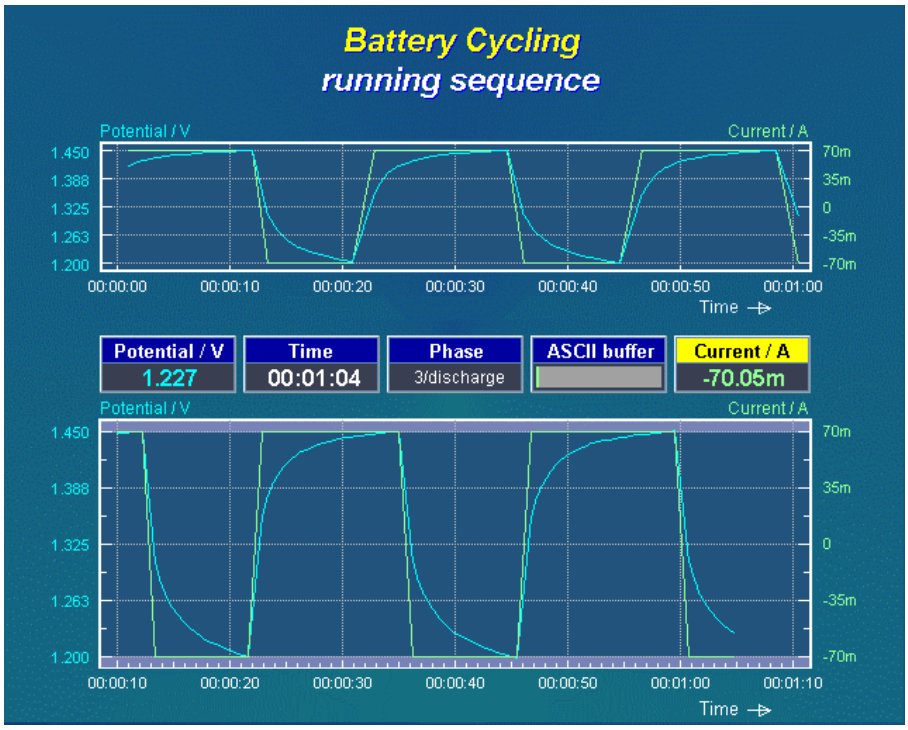
4. Files ____ 15

4.1 ASCII Data List (*.txt) ... 15
4.2 ASCII Data List (*_cl.txt) ... 15
4.3 Log File(*.log) ... 15
4.4 Impedance Rule Files (*.ism) ... 16
4.5 Initialisation File (battcycling.ini) ... 16

Battery Cycling

1. General Information

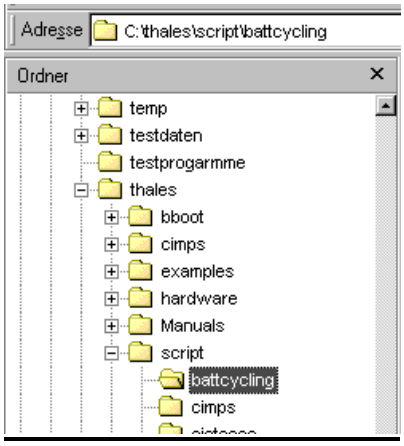
Battery Cycling is a script application for automated DC cycling with AC-EIS spectroscopy during ramps. It's available for the *IM6/Zennium* main potentiostat and external potentiostats like *PP-Series* or *XPOT*.
You can cycle charging and discharging a battery combined with recording impedance spectra during ramps and rest phases for analyzing ageing effects on the characteristics of the battery. The DC measurement data (Time, Potential, Current and Charge) is stored as an ASCII data list file. The charges of each single phase will be stored in an other ASCII file. The recorded impedance spectra are stored together with the ASCII files in a given project folder.



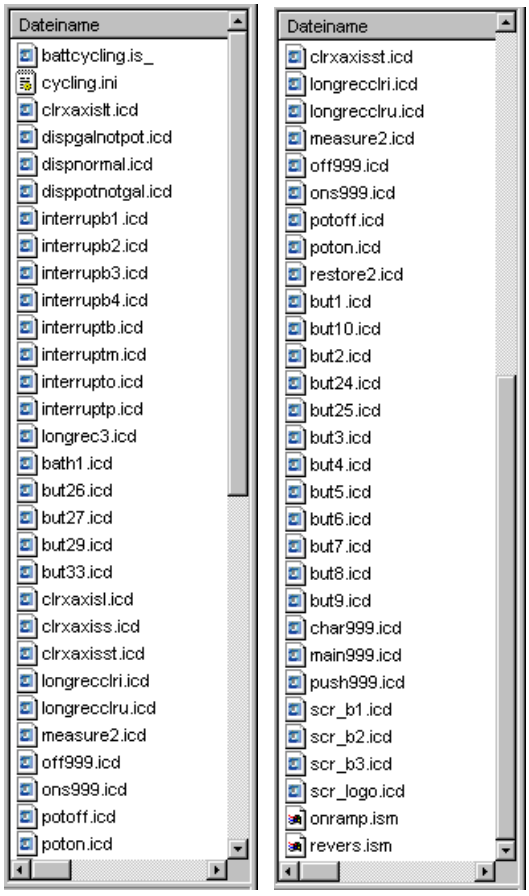
1.1 Resources and Paths

The resources of the script “BATTERY CYCLING” will be found in the directory

c:\thales\script\battcycling



To guarantee the correct translation and operation of the script all files being listed in the table at the right must be present.

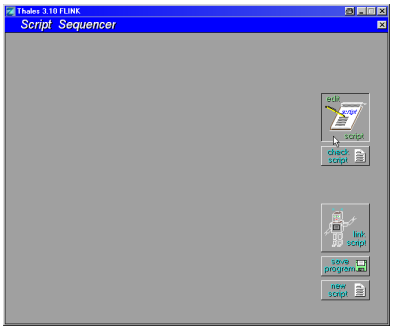


1.2 Generating the Runtime File

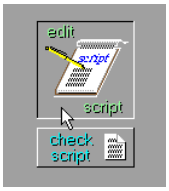
In the following, the creation of the runtime file “battcycling.rtm” will be described. Usually the programme will be installed at ZAHNER and will be found in c:\thales\examples\applications. The start of “battcycling” will be described below (see 1.3. EXE)

The functions of the Thales BATTERY CYCLING are provided in form of a script. Generally, a script can be activated from the Thales desktop by pressing the “script”-button and performing the following procedure:

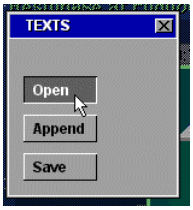
Start “script” from the Thales desktop script icon

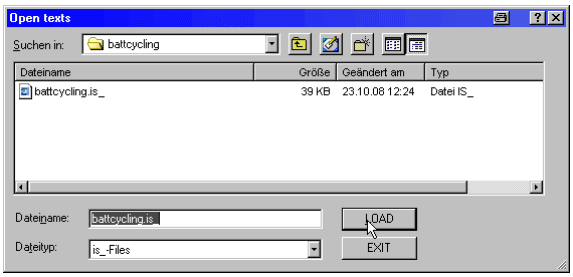


“edit script”

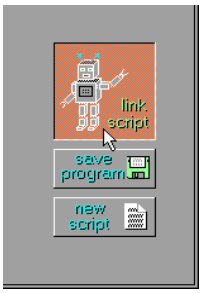


Open source „c:\thales\script\battcycling\battcycling.is_“



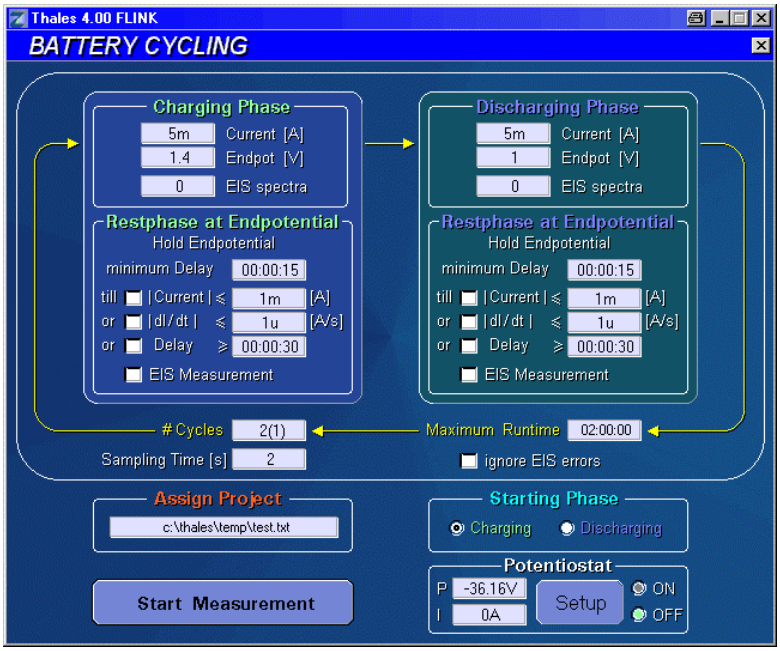


Return to the script panel and link the script



Generally, the source code is open for changes. However, we recommend this only to the experienced user.

After successful linking the BATTERY CYCLING main menu appears:

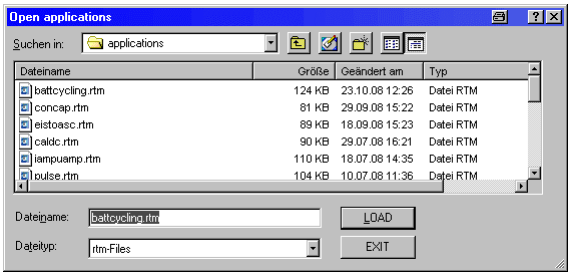


1.3 Starting BATTERY CYCLING by Use of EXE

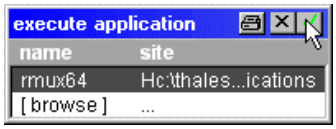
In the path “c:\thales\examples\applications“, usually precompiled versions of script applications are present. Alternatively, to the procedure described above, you can start BATTERY CYCLING like described in the following:

Enter “EXE” from the Thales desktop

Use “browse” to search & start the program needed.

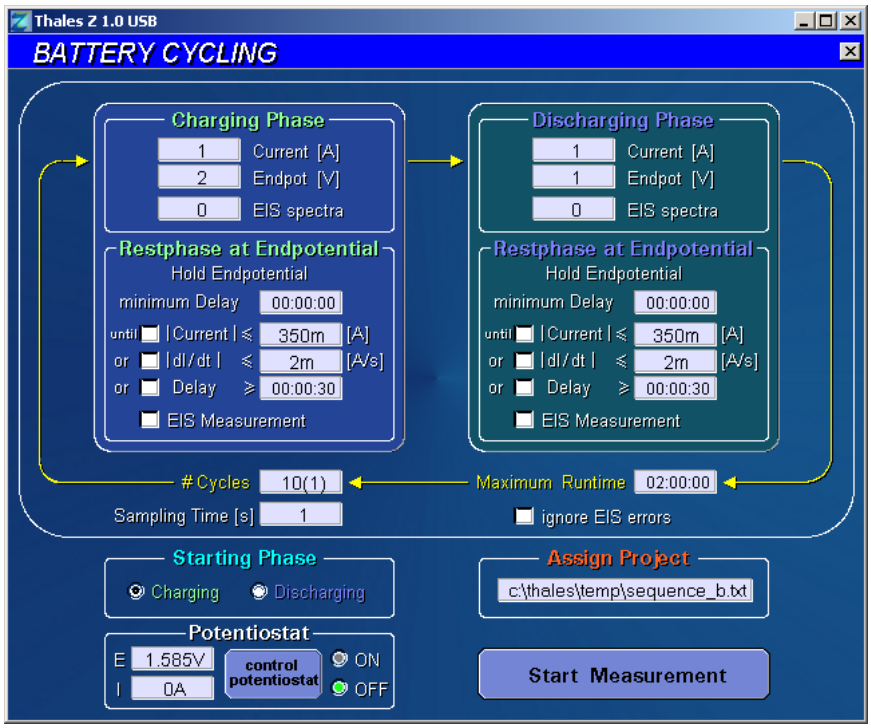


Re-enter by means of EXE, if necessary (right).



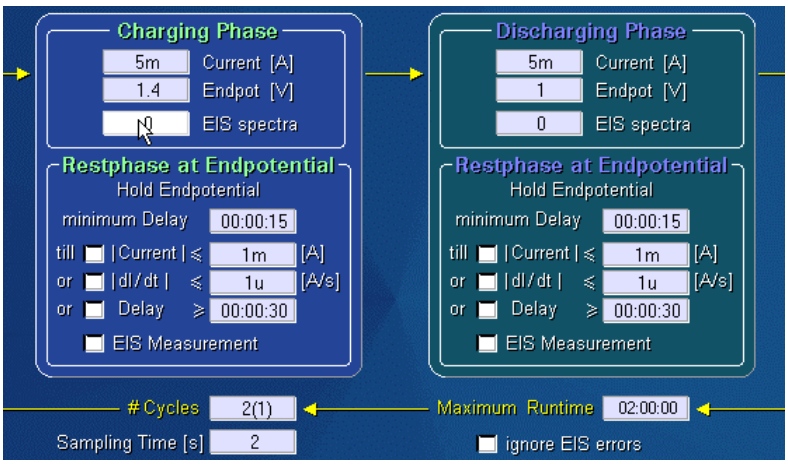
This procedure will save time. However, after exit of BATTCYCLING you will not find BATTCYCLING under the Thales desktop function “script”. Instead, you have to re-enter BATTCYCLING via the EXE function. Pre-compiled versions cannot be altered by the user.

2. BATTERY CYCLING Main Menu



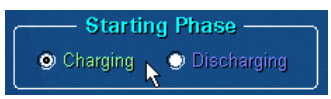
The main menu offers entries

- to modify the runtime parameters of the script



- to define a certain project

- to select an individual starting condition



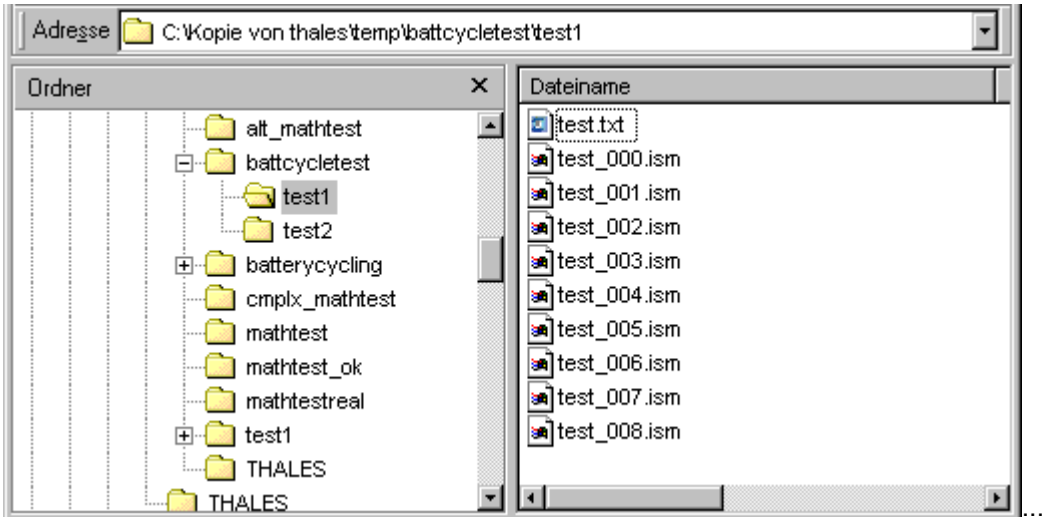
- to set up the potentiostat

- to start the next series

2.1 The BATTERY CYCLING Projects

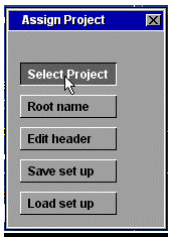
To avoid erroneous overwriting of present data BATTERY CYCLING sequences should be stored as projects. A project will be described by its path and an individual file root name.

The individual files will be named in the following manner, where *.txt is the final ASCII-list and the *.ism-files are being stored in manner of a series measurement.

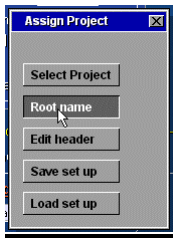


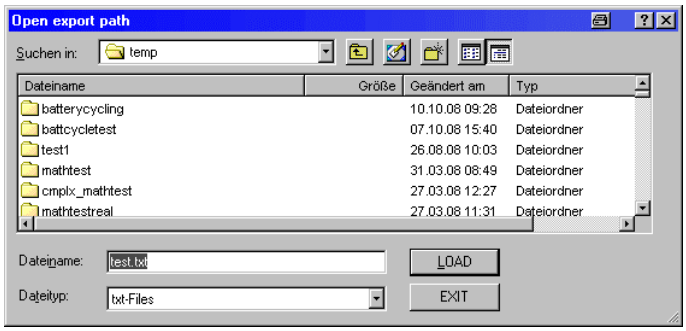
2.1.1 Selection of Projects

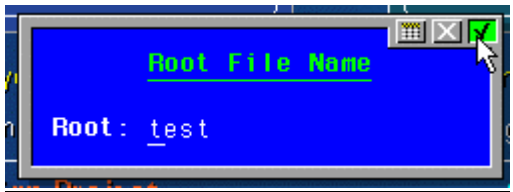
Path



File(s)

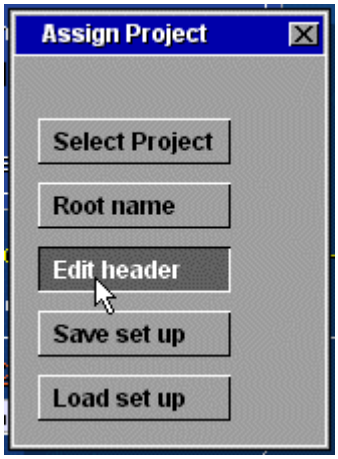


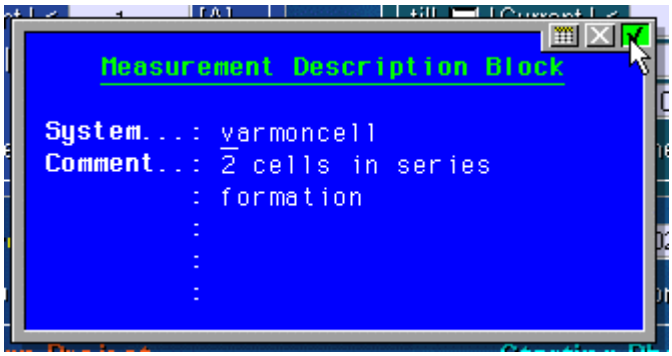




2.2 File Descriptor Block

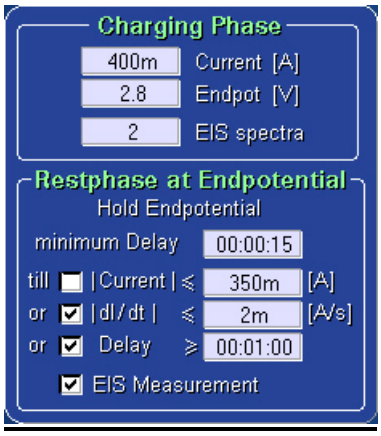
As the impedance spectra will be stored automatically during a cycling project a predefined header for all spectra is being required.





2.3 Description of Runtime Parameters

2.3.1 Charging Phase



The DC parameter of the charging phase are

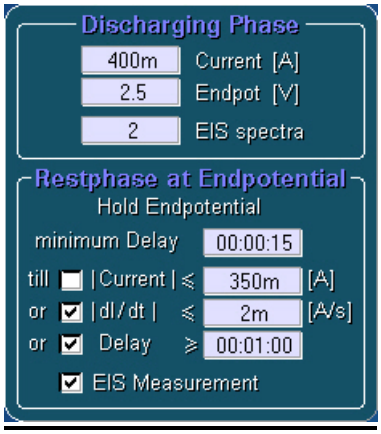
- charging current
- end potential

To measure EIS spectra during the charging ramp use the parameter EIS spectra.

e.g. CEP=2.8V, DEP=1.8V, EIS spectra =3
will result in 3 spectra
at 2.05V, 2.30V and 2.55V

The parameters of the restphase will be described below.

2.3.2 Discharging Phase



The DC parameter of the discharging phase are

- discharging current
- end potential

To measure EIS spectra during the discharging ramp use the parameter EIS spectra.

e.g. CEP=2.8V, DEP=1.8V, EIS spectra =2
will result in 2 spectra
at 2.13V and 2.46V

The parameters of the restphase will be described below.

2.3.3 Restphase

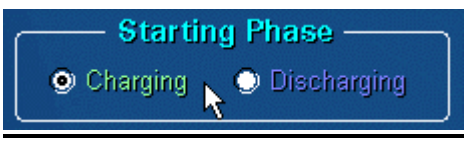
To obtain the best set up (drift, stationarity, etc) for AC impedance measurements at the reversing potentials a stabilisation phase has been established. The system will be fixed potentiostatically at the reversing potential for at least the minimum delay time. After the minimum delay will have run down the following options can be used to determine stability

- the current will go below a certain threshold
- the drift of the current will go below a certain threshhold.
- finally, if none of both will trigger, the script will continue after the maximum delay time will have run down.

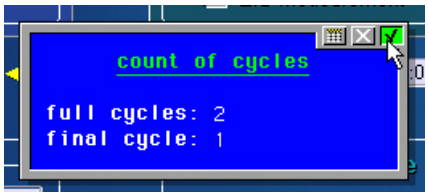
The described options may be selected individually for both phases and are being connected by an logical OR.

2.3.4 Count of Cycles, Runtime and Starting Phase

A cycling sequence will be determined by the count of cycles and the maximum runtime. The mode of the starting phase (charging/discharging) will be selected via

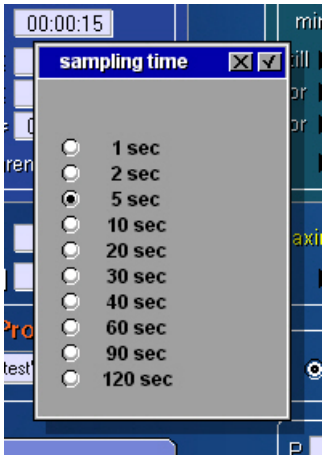


One cycle consist of each a charging and a discharging ramp. After the cycles have run down the battery can be discharged/charged again by an additional cycle (final cycle). Select 1 for a final cycle or select 0 for no final cycle.



2.3.5 Sampling Time

The sampling time of the measured data (time, potential , current and charge) can be selected in a wide range.



2.3.6 Ignore EIS Errors

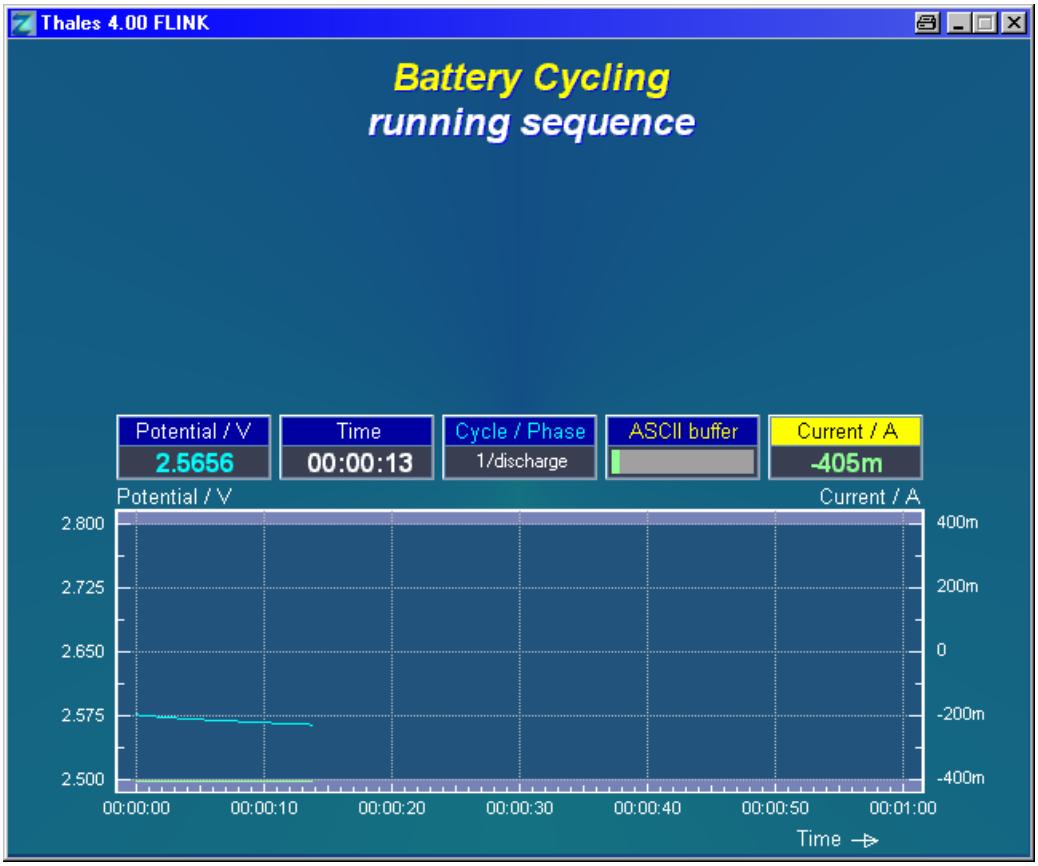
Under certain circumstances the investigated system may become instable during an impedance measurement. Consequently the EIS programme will prompt an error message (e.g. potentiostatic loop interrupted) and the script finally will be interrupted. In case of an active flag ‘ignore EIS error’ the user will accept errors during an impedance measurement and the script will continue with the main cycling process.

3. Next Measurement

3.1 Start Measurement

To start the cycling procedure use the button 

and the data window will prompt:



The measured data will be displayed by means of a ‘storage oscilloscope’ and individual displays. At the left are the displays of potential and time. The current will be displayed at the right hand side. Additional instruments will display the mode of operation (charge/discharge/rest phase) and the state of the ASCII-buffer.

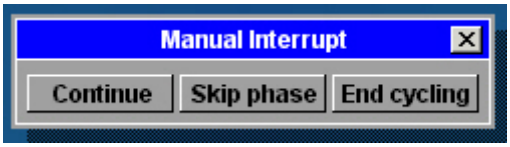
The state of the ASCII buffer is indicated by the colour of the displayed bar (green=OK, orange/red=danger). The dangerous condition will occur in the case that the ASCII data file has been opened by another application and has being write locked by that application (e.g. MS EXCEL). If that case happens the user should quickly close the file in that application or loss of measured date may occur.

The graphs of current and potential will be displayed in individual colours being selected by use of the initialisation file battcycling.ini (see below). Possible colours are

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

3.2 Interrupt of a Running Cycling

To interrupt a running sequence use the ‘escape’-function. An escape will be caused by pressing the middle mouse key or keyboard keys <pos1>-key or <esc>-key. A menu will prompt and ask for the mode of problem treatment.



- Continue go on
- Skip phase continue with next phase
- End cycling stop sequence

The menu will disappear during a refresh of the graphic screen and must be called again.

4. Files

4.1 ASCII Data List (*.txt)

The measured data will be stored in the corresponding ASCII-file ‘project\root.txt’.

Time/sec	Potential/V	Current/A	Charge/C
0.0	2.35586e+00	1.99560e-01	8.18196e-02
1.5	2.38300e+00	1.99553e-01	5.16851e-01
3.5	2.41144e+00	1.99547e-01	9.49868e-01
5.4	2.43714e+00	1.99540e-01	1.29507e+00
7.4	2.46105e+00	1.99543e-01	1.72209e+00
9.5	2.48584e+00	1.99556e-01	2.15114e+00
11.4	2.50659e+00	1.99555e-01	2.49438e+00
17.3	2.39939e+00	-3.78750e-02	2.60023e+00
20.4	2.39939e+00	-1.94200e-02	2.48414e+00
22.3	2.39939e+00	-1.17286e-02	2.42429e+00
.	.	.	.
.	.	.	.
.	.	.	.

4.2 ASCII Data List (*_cl.txt)

The charges of each single phase will be stored in the corresponding ASCII-file ‘project\root-cl.txt’.

cycle	Ccha/C	Cdis/C
1	8.77527e+00	-5.31125e+00
2	5.68430e+00	-5.48984e+00
3	5.75407e+00	-5.46988e+00
4	5.60219e+00	-5.53821e+00
5	5.69388e+00	-5.45616e+00
6	5.60992e+00	-5.54249e+00
7	5.60585e+00	-5.45631e+00
8	5.69951e+00	-5.62676e+00
9	5.62158e+00	-5.53870e+00
10	5.61162e+00	-5.54076e+00
11	5.61939e+00	-5.62709e+00
12	5.76897e+00	-5.55899e+00
13	5.77104e+00	-5.90578e+00

4.3 Log File(*.log)

The Log file will store information about the impedance spectra being recorded

Time/sec	Potential/V	Phase	File
3.4	2.0	1/cha	burki_000
33.6	2.2	1/cha	burki_001

```
    .           .           .           .
    .           .           .           .
  113.3         2.2         1/dis       burki_003
  143.1         2.0         1/dis       burki_004
    .           .           .           .
    .           .           .           .
  254.3         1.6         2/cha       burki_008
  279.2         1.8         2/cha       burki_009
    .           .           .           .
    .           .           .           .
```

4.4 Impedance Rule Files (*.ism)

To set up the AC parameters of the impedance measurements (frequency range, frequency resolution, amplitude, averaging etc.) predefined impedance data files are being used.

Note!	These files must be stored in the project's root directory c:\thales\script\battcycling

Two files have been prepared to set up different conditions during a ramp (=onramp.ism) and at the reversing points (revers.ism).
If you consider series evaluation of the spectra being recorded both rule files should be identically.

4.5 Initialisation File (battcycling.ini)

During the start of a new cycle the initialisation file ‚c:\thales\script\battcycling\battcycling.ini' will be created. During the next start up of the cycling script that file will be read to preset the parameters to a well defined default set up (user defined set up).
The used parameters are being stored by means of description texts. The ´:`-character is the delimiter being followed by the value of the corresponding parameter.

DO NOT change the format of the parameter lines, DO only modify the parameters.

```
Charging     Current        :5m
             End Potential  :1.4
             EIS spectra    :0
             minimum delay  :00:00:15
             End Current    :1m
             Stationarity   :1u
             Restphase      :00:00:30
Check        End Current    :off
             Stationarity   :off
             Restphase      :off
             Impedance      :off
Discharging  Current        :5m
             End Potential  :1.0
             EIS spectra    :0
             minimum delay  :00:00:15
             End Current    :1m
             Stationarity   :1u
             Restphase      :00:00:30
Check        End Current    :off
             Stationarity   :off
             Restphase      :off
             Impedance      :off
Runtime      # of cycles    :2.5
             max. runtime   :02:00:00
             sampling time  :2
Starting     Phase          :charging
Project      PATH           :c:\thales\temp
             Rootfile       :test
HEADER       System         :
             Comment1       :
             Comment2       :
             Comment3       :
             Comment4       :
             Comment5       :
Color        UDATA          :6
             IDATA          :8
EIS          Rule Ramp      :onramp
             Rule Reverse   :revers
             Ignore Errors  :0
RESERVED40                  :reserved for future
...
...
RESERVED64                  :
End
```