

Questions & Answers

What kind of problems are addressed?

Too much stimulation amplitude or failure to reach the system steady-state may corrupt data. There may also be too much noise.

Why are they useful?

They help to quickly assess the validity of an impedance measurement.

How many indicators?

There are three indicators:
THD (Total Harmonic Distortion)
NSD (Non-Stationary Distortion)
NSR (Noise to Signal Ratio)

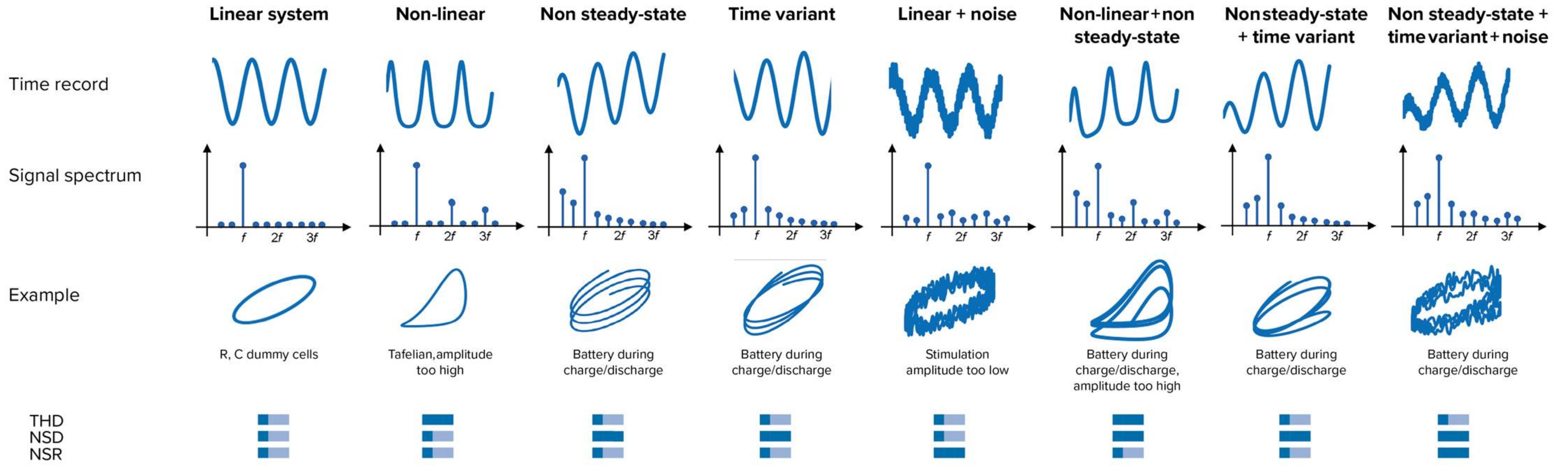
How are they calculated?

They are calculated for each impedance point from particular frequencies of the current and potential spectra.

How to interpret them?

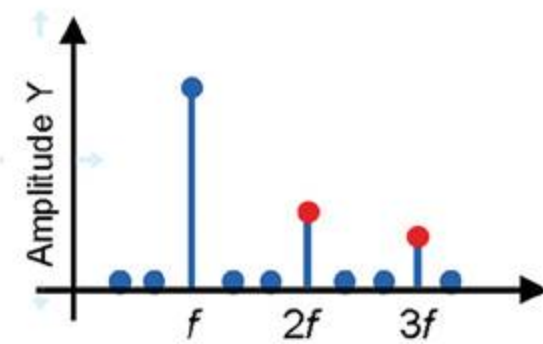
Values above a certain level indicate a problem. A high THD indicates a linearity issue, a high NSD indicates a non-stationary issue, while a high NSR indicates a noise issue.

Response of different systems to a sinusoidal stimulation



Total Harmonic Distortion (THD)

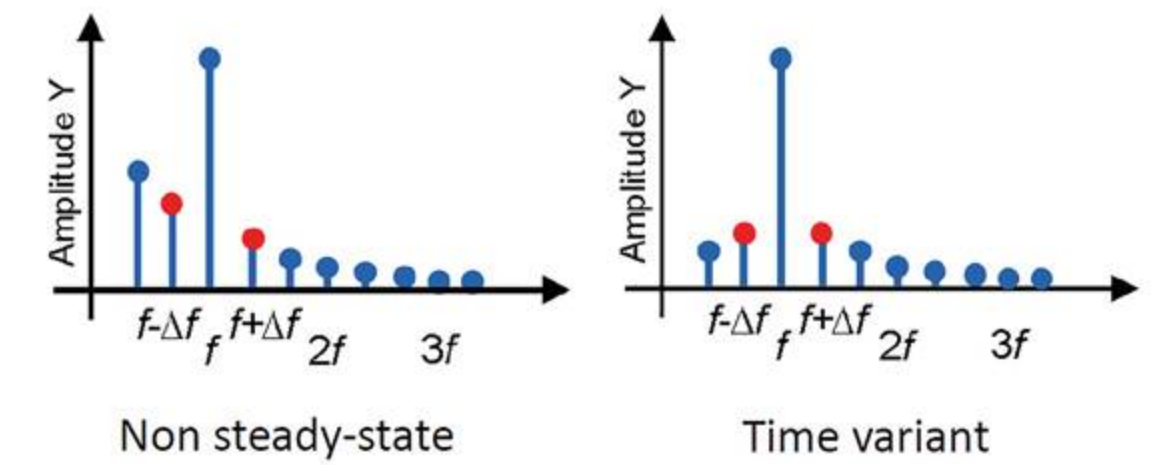
$$THD_f = \frac{1}{Y_f} \sqrt{\sum_{k=2}^N Y_{kf}^2}$$



The THD is computed at each frequency as the ratio of the RMS value of the higher harmonic frequencies ($Y_{2f}, Y_{3f}, Y_{4f}, \dots$) to the amplitude value of the first harmonic or fundamental frequency Y_f .

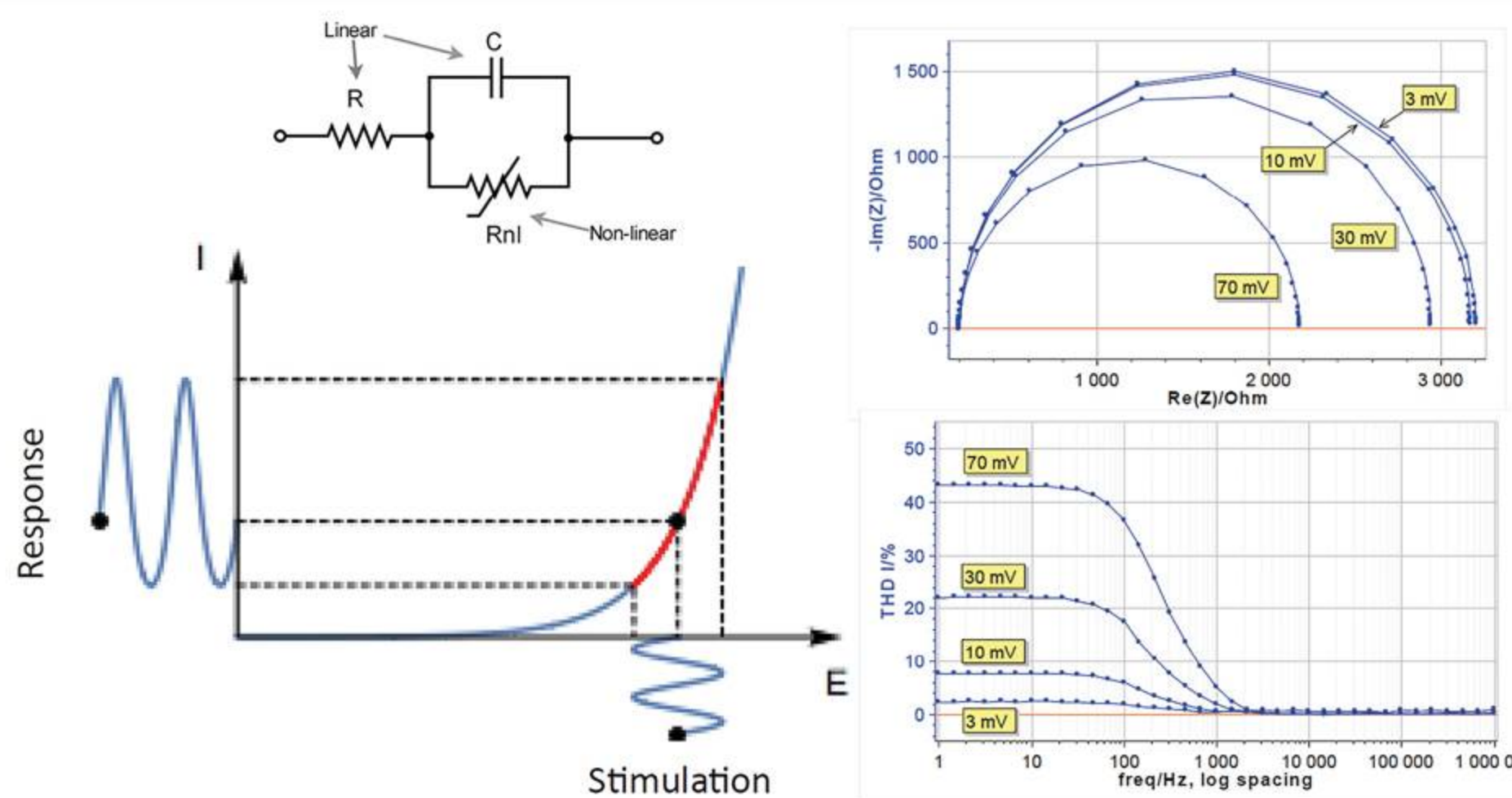
Non-Stationary Distortion (NSD)

$$NSD_f = \frac{1}{Y_f} \sqrt{Y_{f-\Delta f}^2 + Y_{f+\Delta f}^2}$$



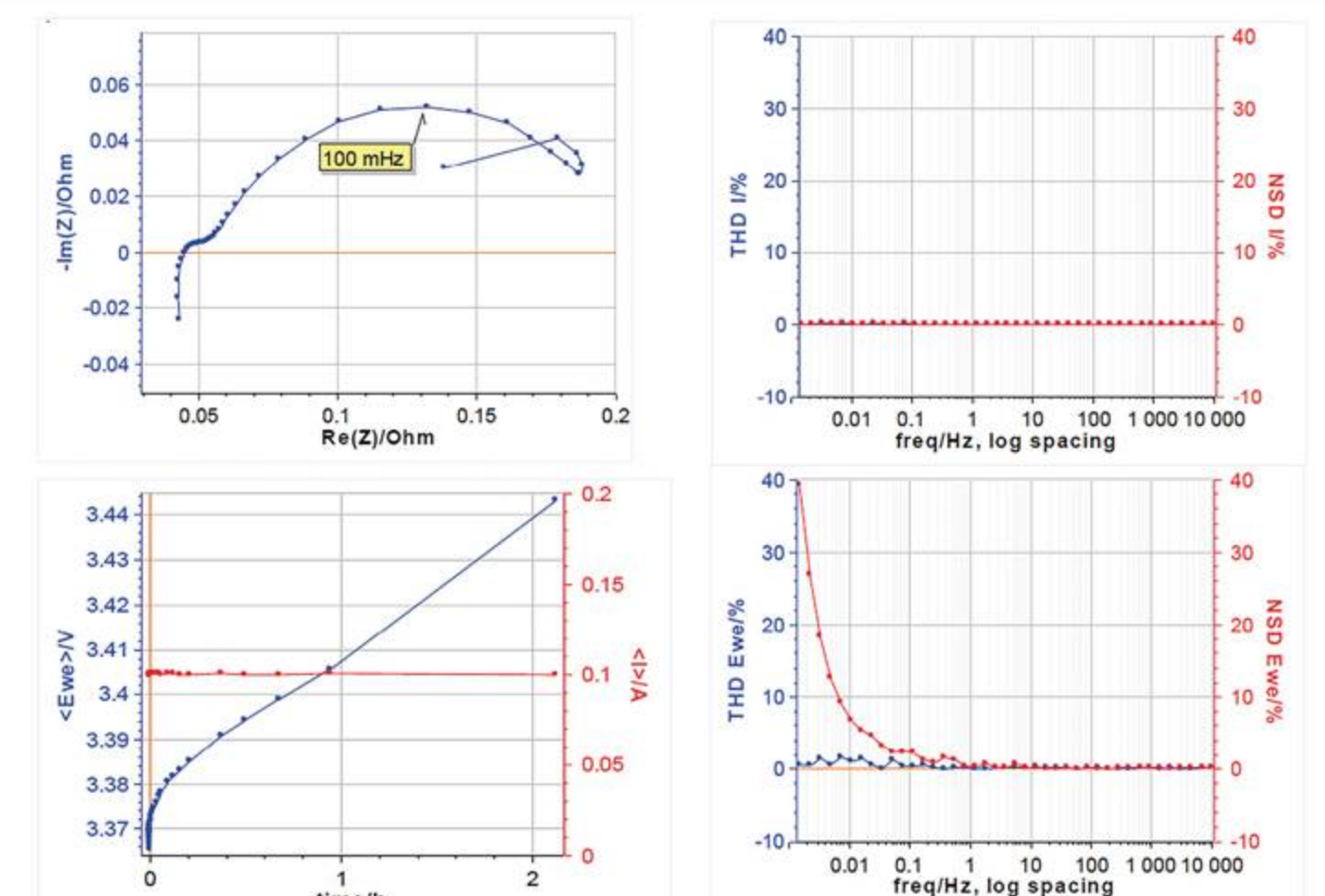
The NSD is computed at each frequency as the ratio of the RMS amplitude of the near-side frequencies ($Y_{f-\Delta f}, Y_{f+\Delta f}$) to the amplitude of the fundamental frequency. The NSD counts for both time variant systems and non steady state measurement conditions.

Non-linear Tafelian system



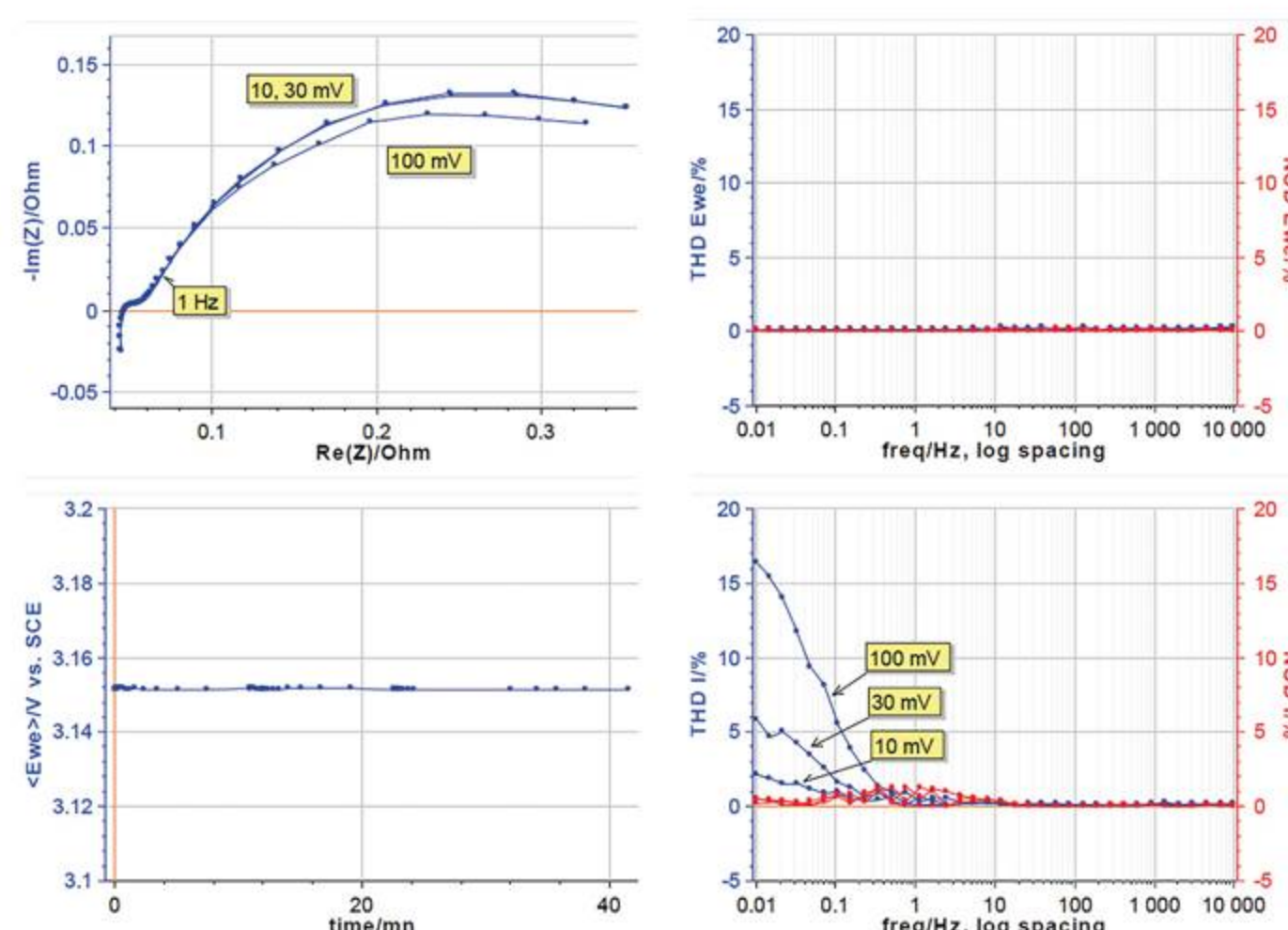
EIS during charge

Current controlled EIS-AA (Adaptive Amplitude) during charge on a commercial 3 Ah Li-ion 18650 battery :
 - 10 kHz to 2 mHz
 - 10 mV AC amplitude
 - 100 mA DC charging current



What level of amplitude?

Voltage controlled EIS at open circuit voltage on a commercial 3 Ah Li-ion 18650 battery :
 - 10 mV, 30 mV and 100 mV
 - 10 kHz to 10 mHz



EIS during corrosion

Six successive voltage controlled EIS results during the corrosion of a steel sample in sulfuric acid :
 - 100 kHz to 10 mHz
 - 20 mV AC amplitude

