Ivium Electrochemical Note IEN4

Automatic current ranging

Most potentiostats have the ability to automatically select the best current range, based on real-time measurements. This note describes how this works, with the advantages and disadvantages.

The advantages:

- Convenience. If you do not know in advance what to expect, this feature comes in handy.
- Enlarge the dynamic range. Some DC scans encounter exponential voltage relations, so it needs to switch up/down during the scan to avoid overloads/underloads. An EIS frequency-scan can encompass many impedance decades, so it needs to be able to switch the range automatically, to use the most appropriate range for each frequency.
- Cope with bandwidth variations. During a EIS scan, the most optimal current range is different for each frequency due to the relation range with bandwidth. Setting it to AutoCR ensures proper choices of current range.

The disadvantages:

- Introduces discontinuities. Each range has its own gain-error, so when the range is switched, the mismatch between 2 ranges can potentially cause a small step in the result. Even with a small mismatch of 0.2%, it will be visible when you zoom into the plot.
- Range switching takes time. AutoCR cannot be used for high-speed sampling, because the mechanical relays require time to switch.
- Limits the analog filter. AutoCR limits the range of analog filtering, because the signal processor needs to be able to settle on the new range fast enough, and therefore filtering will be (slightly) sub-optimal.

The “best” current range is determined from 3 properties:

1. Overload level, by default 2.5x Current Range. If the measured current exceeds this, it switches to a higher range.
2. Underload level, by default 0.05x Current Range. If the measured current remains below this value for 3 consecutive datapoints, it switches to a lower range.
3. Bandwidth requirement. From the interval time (DC), or frequency (EIS), the minimum required Current Range is determined. At higher frequencies, higher current ranges are selected.

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