Ivium Electrochemical Note IEN1

Gained vs. true current ranges

Often in potentiostat datasheets, a distinction is made between "true" and "gained" current ranges. This note describes the difference and the practical implications.

In most cases, the current is determined by running it through a resistor, over which the voltage is measured. There are 2 basic methods for creating variable ranges:

a. Switching the measurement resistor = True Range
b. Amplifying the voltage with various gain factors = Gained Range

True ranges are more accurate and have lower noise:

- For a gained range, the offset (drift) error will be multiplied with the gain factor. Therefore, its error is the gain factor higher than for an equivalent true range.
- For a gained range, the input voltage noise from the electronic amplifier is multiplied with the gain factor.
- For a gained range, the thermal noise from the measurement resistor scales with the gain factor proportionally, whereas for a true range it scales with the SQRT(factor). Thus, a 100x gained range has 10x more thermal noise than a true current range.

Gained ranges are faster, and cheaper to produce:

- Using a gained range saves on expensive mechanical relays and accurate (high)ohmic resistors.
- Because lower ohmic measurement resistors are used with the same capacitor, a lower RC time will be achieved, and therefore the current measurement is faster.

Usually, true ranges are more desirable because these gives a higher quality result. Nevertheless, some situations can arise where gained ranges have merit: at very low currents.

- High ohmic resistors can be prohibitively expensive or are sometimes impossible to obtain.
- At such high ohmic values, the parasitic capacitance would make measurement too slow, to be practical.

In such cases, it can be justified to use gained ranges for the lowest current ranges. At the present state of technology, the advisable maximum factor for gained ranges is:

- 100x for DC measurement
  - Good electronic amplifiers have below 10uV offset, so the error remains below 1mV.
- 10,000x for AC measurements:
  - AC measurement accuracy is less affected by offset errors.
  - Fourier analysis can achieve a narrow bandwidth and can live with more noise.

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