Last document update: December 18, 2020

Application Note

This Application Note also applies to EmStat Pico powered instruments including the Sensit BT and Sensit Smart.

Running an EIS measurement on a chip

Electrochemical Impedance Spectroscopy (EIS) measures the change of the complex impedance over a frequency range (spectrum). The common way to calculate the complex impedance is by dividing the complex voltage by the complex current. The ADUCM355 has only 1 ADC so it is not possible to measure both signals (voltage and current) at the same time, the proposed solution to enable EIS measurement using only the current signals is a 3-stage measurement. The total EIS measurement for one single frequency point is split up into three measurements on three different impedances:

1. Zcell + Rload
2. Rload (load resistor in the WE signal path)
3. Rcall (calibration reference resistor)

Since all three measurements are performed under the same conditions and Rcall is a reference resistor of known value, the final complex impedance of Zcell can be calculated having only the complex currents of the three measurements.

Complex voltage correction

For the plain ADuCM355 the conditions for the 3 measurements are equal, for the Emstat Pico the measurement on the Zcell+Rload is performed using external RE-buffers introducing a complex transfer function for the applied AC voltage on the Zcell+Rload. This complex voltage transfer function is modeled by an electronic circuit simulation of the gain and phase behavior of the transfer function.

Time-domain sinewave

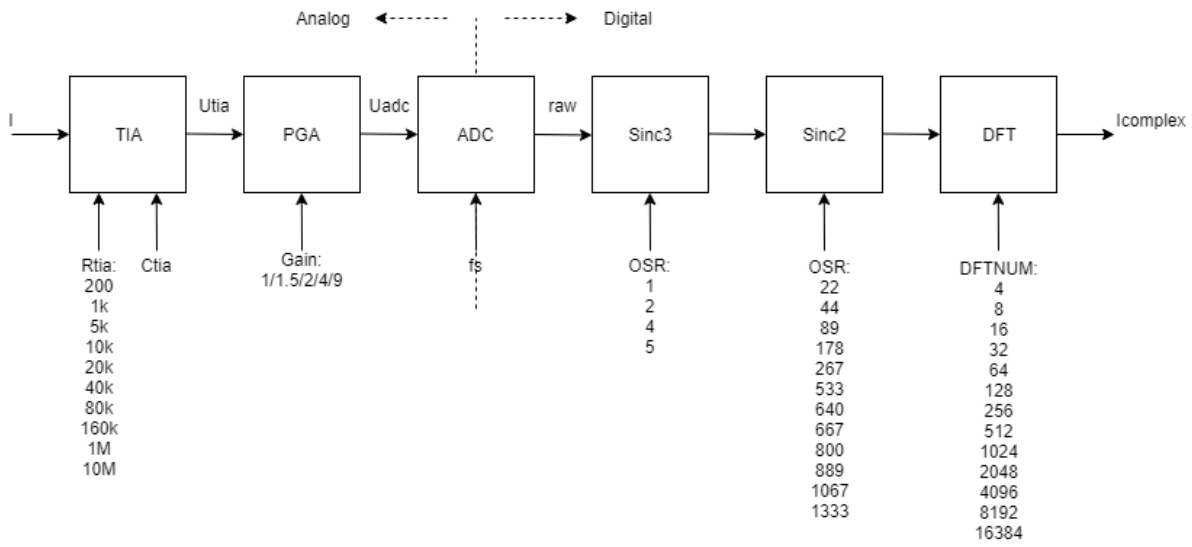
The Emstat Pico integrates a DFT calculation block enabling onboard complex current calculations. In contrast to other Palmsens devices having the EIS feature, the raw ADC signal is not available and therefore the time-domain signal cannot be shown in a host application (PSTrace, PStouch)

Measurement duration

The accuracy of the complex current depends on the number of the applied frequency cycles presented to the DFT process. For higher frequencies, the time to measure multiple cycles is relatively short in contrast to the lower frequencies. For example, measuring 8 cycles of 1 Hz takes 8 seconds resulting in a 24 second measurement duration for a complete 3-stage measurement.

Current ranges

Since the conditions must be the same, all 3 measurements must be performed using the same current range. Rload (~100 Ω) and the Rcall (1 kΩ or 100 kΩ) are fixed values, however the complex current measurements are frequency depended due to parasitic effects of the signals path. The changes of Zcell vs frequency can be so large that it cannot be covered by staying in the same current range. Auto current ranging dynamically changes the current range (in combination with the PGA) to cover the frequency range in the EIS measurement.



DFT signal path block diagram for EmStat Pico

More details can be found in the ADuCM355 Hardware Reference Manual- UG-1262 p137-p143.