Characterization of Analog-to-Information Converters

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The dissertation deals with the characterization of sub-sampling devices, the Analog-to-Information Converters (AICs), recently proposed in research as an alternative to the traditional Analog-to-Digital Converters. By exploiting the Compressive Sampling paradigm, AICs stably recover the input signal, previously acquired with less samples than needed by the Nyquist-Shannon theorem, reducing simultaneously sampling frequency and acquisition memory. The dissertation research was carried out in order to design and develop an AIC prototype to be employed in a measurement instrument: a vector signal analyzer, that acquires and reconstructs sparse wideband signals. The aim of such an instrument is to guarantee proper monitoring, circumventing the trade-off between resolution and sampling frequency, typical of conventional data acquisition systems. With a view to this use, the characterization of AICs is of crucial importance, since their performance conditions the measurement instrument based on them, and, although several efforts have been made in research to propose several architectures, only in a few cases their performance is assessed.

Firstly, a state of the art on AICs is presented in the dissertation, by classifying the existing architectures, prototypes and models. Then, the dissertation focuses on the characterization of AICs, by identifying non-idealities affecting the individual components and by recommending testing methods and corresponding figures of merit for AIC assessment, differentiating them in methods before and after the reconstruction of the input signal. Specifically, a new figure of merit adopted before the reconstruction is proposed. Thus, the experimental contribution of the dissertation is presented: the analysis of AIC performance, depending on the non-idealities through the aforementioned figures of merit. In particular, two categories of AICs are considered for the metrological characterization: (i) the Random Demodulation (RD) AIC and the similar counterpart structured on parallel channels, the Modulated Wideband Converter (MWC); (ii) the Non-Uniform Wavelet Bandpass Sampling (NUWBS) AIC. With regard to the first AIC category, several investigations were performed: the comparison between two mathematical models for the same prototype and the analysis related to non-idealities of the two building blocks involved in the modulation of the input signal, i.e. pseudo-random sequence and mixer. With regard to the second category, several investigations were performed as well: the analysis related to main noise sources and the experimental assessment of a proposed prototype employing a low pass-filter instead of an analog integrator.

Based on the results of the dissertation (Fig. 1), on one hand, the experimental analysis suggests the use of specific components rather than others to implement the AIC board for the vector signal analyzer, namely an analog multiplier instead of a mixer, to reduce the distortion phenomenon, or a Wavelet signal, if the monitored frequency interval of the input signal requires to be extended. On the other hand, the numerical analysis suggests key aspects on the measurement matrix to be adopted in the reconstruction phase, such as the importance of including architectural non-idealities and actual features of the prototype, first of all the pulse shape of signals involved in modulation processes and the impulse/frequency response of filters located ahead ADCs working at sub-Nyquist rates.

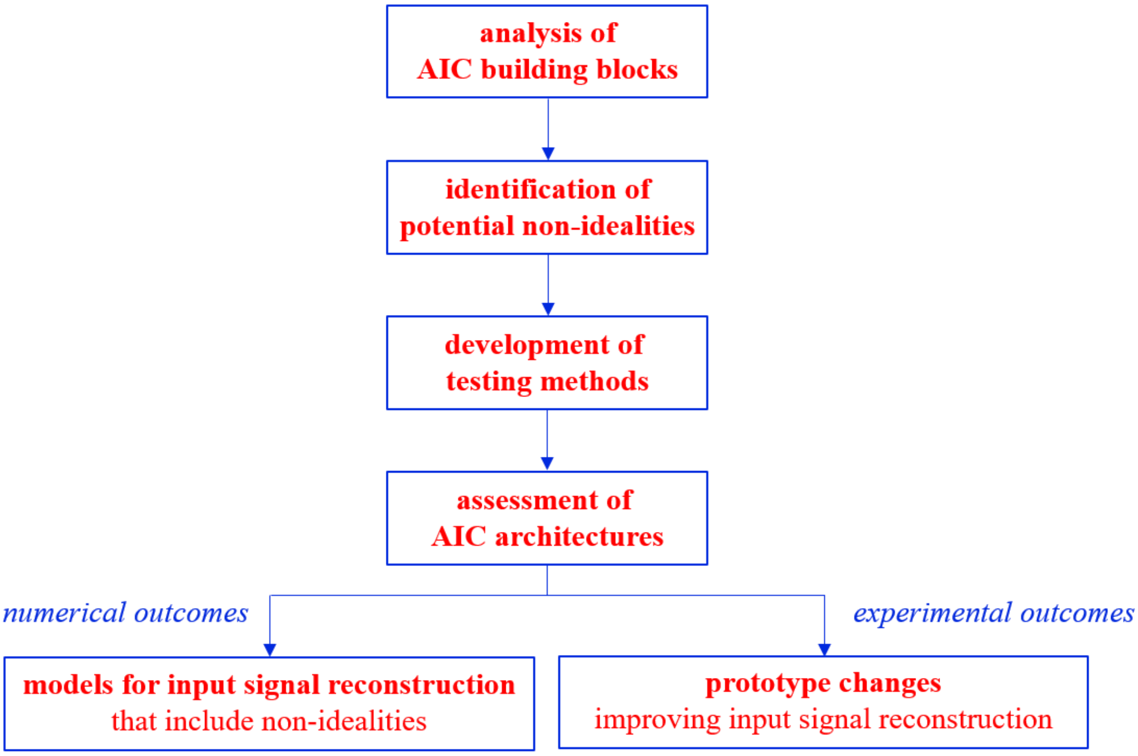

Fig. 1. Phases for characterization of AICs.

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