Comparison of Parameters of Systems Used for AD Converters and Modules Testing

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Abstract: The paper presents results of ADC testing systems comparison between Laboratoire de micro-électronique IXL, University Bordeaux and ADCM&T Laboratory, Dept. of Measurement of FEE CTU, Prague. The comparison was performed using transportable reference AD device designed and developed in FEE CTU.

Keywords: ADC Testing, Reference AD Device, Comparative measurement.

INTRODUCTION

The evaluation of systems designed for a dynamic testing of ADCs or AD modules is not easy. The quality of testing signal, sampling synchronization, signal processing, EMC conditions etc. can significantly influence the credibility of achieved results. Moreover, the evaluation of testing systems is very difficult, because there is no reference digitizer or testing methods with a significantly higher precision. Therefore only the comparative measurement comes into consideration and this one can discover the weaknesses of used methods and systems.

In spite of well-known methods of ADC dynamic testing (FFT Test, Best Sinusoidal Curve Fit Method, Histogram Test) standardized in the IEEE Standard for Digitizing Recorders [1], or IEEE Standard for Terminology and Test Methods for Analog-to-Digital Converters [2], there is a number of problems their implementation. The number of laboratories, which are interested in ADC testing, developed new methods and systems for it in the last several years (see e.g. [3 - 6]). To assess the real precision of realized testing systems and to compare advantages and disadvantages of applied methods, comparative measurements should be executed. To be possible to execute the comparative measurement, a transportable high stable reference AD device was designed and the first prototype was realized in Dept. of Measurement of FEE CTU in Prague [7]. The whole design was made with a view to a high stability and an internal disturbance minimization.

According to the first experience, some changes of shielded AD module were made (see Fig. 1). The basic description of present version of AD module follows:

- switching input impedance 1 kΩ / 50 Ω
- input voltage ± 5 V gain G = 2, (the input range of the ADC used is ± 10 V)
- operational amplifiers AD845: gain 250.10^3, full-power bandwidth 12 MHz,
- ADC with successive approximation: AD976A (16-bit/200 kHz),
- voltage reference AD 780 (2.5 V).

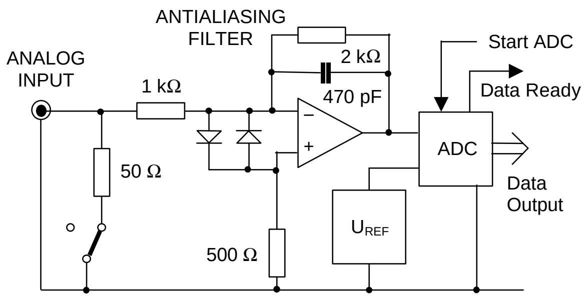


Figure 1. Simplified connection of the input module

COMPARISON OF ADC TESTING SYSTEMS

The comparative measurements were executed in Laboratoire de micro-électronique IXL, University Bordeaux.

All parameters of the transportable reference AD device were measured before leaving in Bordeaux using measuring system for AD modules testing including the software package Digester developed in ADCM&T Laboratory, Dept. of Measurement of FEE CTU in Prague during last three years. The system, which consists of a host PC, VXI system with the digitizer HP E1430A, and the low-distortion generator Stanford Research DS360 was modify for this case. The logic analyzer Tektronix TLA 720 was used for direct data recording from the transportable reference AD device.

The all measurement were executed in non-coherent mode (the used generator does not enable phase synchronization) both with an internal and an external source of clock pulses. The sampling frequency 156250 Hz was used in all cases.

The system used in IXL Bordeaux consists of a host computer Apple with logic analyser plug-in board and several generators. The low distortion generator B&K 1049 was used for comparative measurement. Both the non-coherent and coherent measurements were executed. The software package CanTest developed in IXL was used for the result processing.

ACHIEVED RESULTS

Processing of measured data was performed using software mentioned above (Digester - Prague, CanTest - Bordeaux). In order to evaluate accuracy of these software packages the data measured in Bordeaux were processed both ones.

The B&H 7-term window was used in the case of non-coherent sampling. Relevant results of comparison are presented in Tab. 1.

The Fig. 2 shows that the values of effective number of bits measured in both laboratories are practically the same. There is also a little difference in the other parameters (THD, amplitudes of significant harmonic and spurious components etc.). As example, some measured spectra at frequency 1.333 kHz are shown in the Fig. 3 and at frequency 20.333 kHz in the Fig. 4.

All the files with data of measurements executed both in Bordeaux and in Prague were archived, and they are at disposal for all possible applicants.

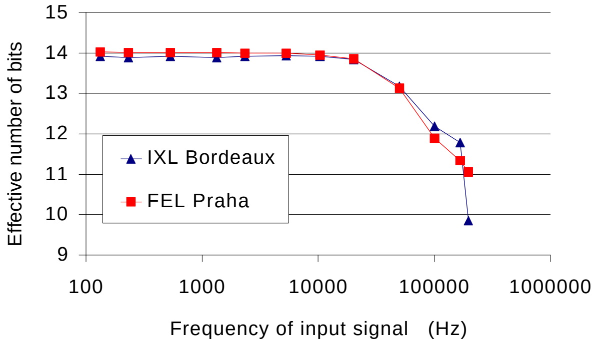


Figure 2. Measured effective number of bits, non-coherent internal sampling (FFT, B&H 7term window)

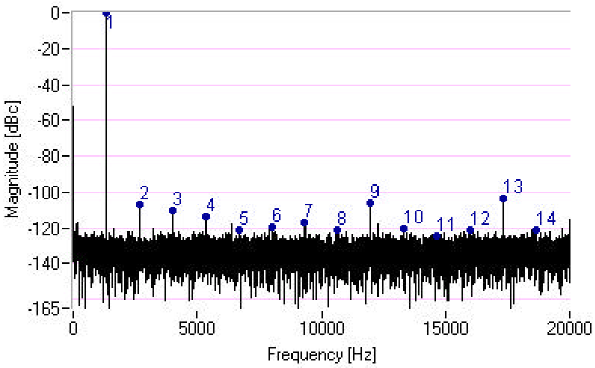
CONCLUSIONS

In principle the same ADC testing methods were used in both laboratories (FFT test, 7-term Blackman–Harris window). The same results were achieved with the same input data, thus the main difference lies in various harmonic generators used. Stanford Research DS360, used in laboratory ADCM&T, appears to be slightly better in spectral purity and THD than Bruel&Kjaer 1049 in laboratory IXL but on the other hand SR DS360 does not support phase synchronisation necessary for coherent sampling.

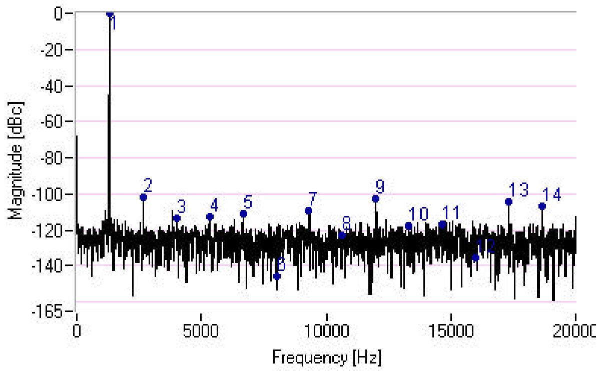
Moreover, logic analyser in laboratory ADCM&T enables to gain four times more samples and so more details in frequency spectrum (four times better frequency resolution and lower noise floor by -6 dB).

	PRAGUE, non-coherent sampling f_{Sa} = 156.25 kHz; N = 128 kSa			BORDEAUX, non-coherent sampling f_{Sa} = 156.25 kHz; N = 32 kSa		
f (Hz)	ENOB (–)	SINAD (dB)	SNR (dB)	ENOB (–)	SINAD (dB)	SNR (dB)
133	14,01	86,13	86,37	13,91	85,52	85,67
233	14,02	86,15	86,28	13,89	85,41	85,58
533	14,02	86,16	86,37	13,92	85,58	85,72
1 333	14,01	86,08	86,29	13,89	85,38	85,50
2 333	14,01	86,10	86,31	13,92	85,56	85,64
5 333	14,00	86,04	86,25	13,93	85,60	85,67
10 333	13,98	85,93	86,06	13,89	85,36	85,46
20 333	13,83	85,05	85,35	13,69	84,20	85,30
50 333	12,66	77,98		12,54	77,25	
100 333	11,74	72,43		11,77	72,62	

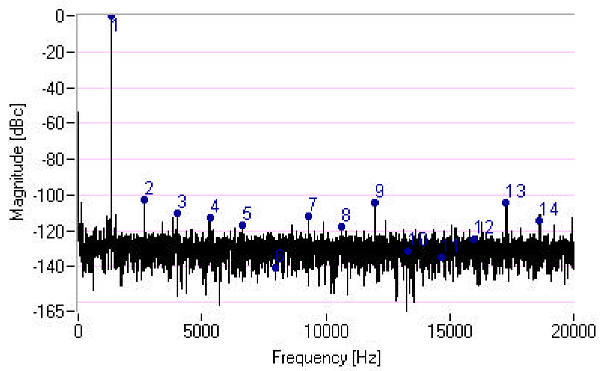
Table 1. Results of ENOB, SINAD and SNR measurements of ADC reference box



a) PRAGUE, Non-coherent sampling, N = 128 kSa
ENOB = 14.01, *SINAD* = 86.08 dB, *SNR* = 86.28 dB



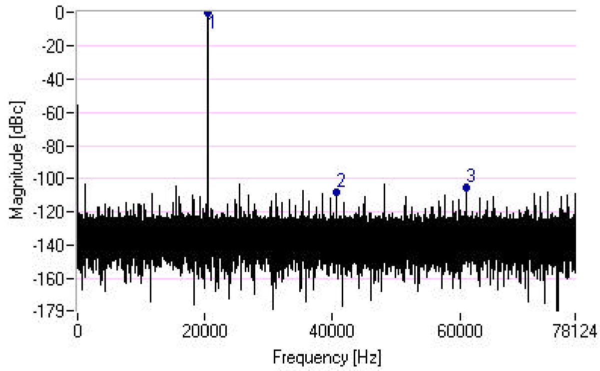
b) BORDEAUX, Non-coherent sampling, N = 32 kSa
ENOB = 13.89, *SINAD* = 85.38 dB, *SNR* = 85.50 dB,



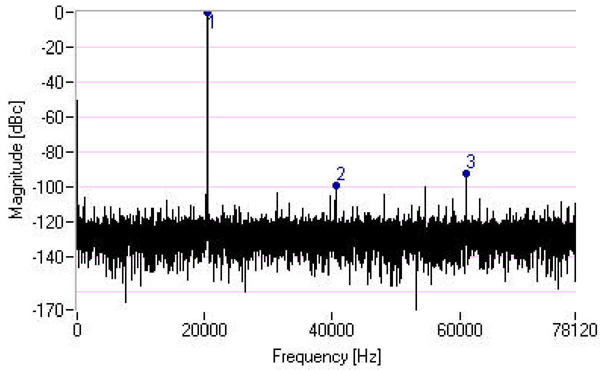
c) BORDEAUX, Coherent sampling, N = 32 kSa
ENOB = 13.88, *SINAD* = 85.30 dB, *SNR* = 85.41 dB

Figure 2. f_{in} = 1.333 kHz, U_{rms} = 3.7 V

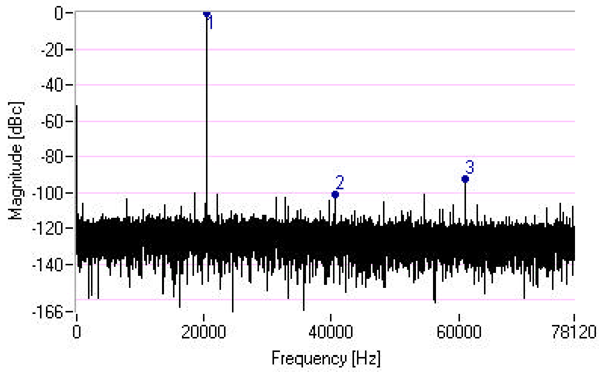
Nevertheless, the results from both laboratories are practically the same and the difference is mostly only 0.15 ENOB (for testing signal up to 100 kHz).



a) PRAGUE, Non-coherent sampling, N = 128 kSa
ENOB = 13.83, *SINAD* = 85.05 dB, *SNR* = 85.35 dB



b) BORDEAUX, Non-coherent sampling, N = 32 kSa
ENOB = 13.69, *SINAD* = 84.20 dB, *SNR* = 85.30 dB,



c) BORDEAUX, Coherent sampling, N = 32 kSa
ENOB = 12.93, *SINAD* = 79.59 dB, *SNR* = 79.86 dB

Figure 3. f_{in} = 20.333 kHz, U_{rms} = 3.7 V

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