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EVALUATION OF SHORT-TIME INSTABILITY OF GENERATORS USED FOR ADC TESTING

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Abstract – The quality of an evaluation of dynamic parameters of ADCs and AD modules is strongly dependent on the quality of testing signal generator. The most important parameters are the signal to noise ratio (*SNR*) and the spectral purity (*THD*). Besides, the short-time frequency and amplitude stability are also necessary to be considered, but it is often marginalized. However, they also influence the accuracy of the further evaluation. A possibility, how to estimate this imperfection, is presented in the paper.

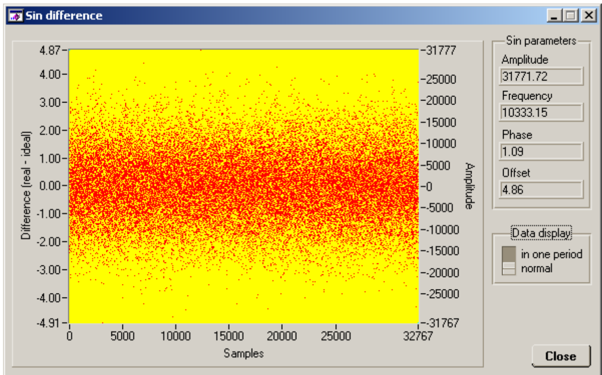
Keywords: ADC testing, testing signal, short-time instability

1. INTRODUCTION

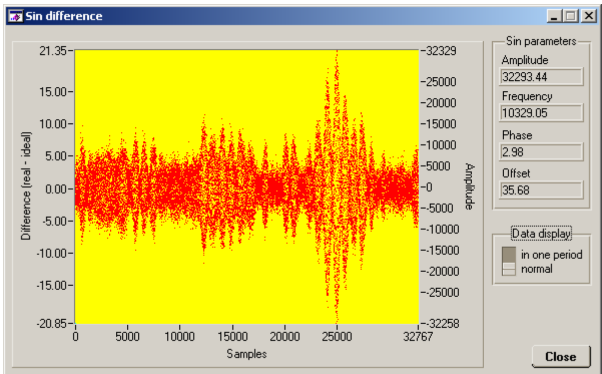
Low-distortion generators are usually used for testing the dynamic quality of ADCs and AD modules. Generators based either on classical tuned low-distortion oscillators or digital frequency synthesis are used for this purpose. Since more then one sinus period is usually sampled (several tens or hundreds), a problem of the short-time instability (frequency and amplitude) of testing signal arises. It concerns primarily the non-coherent sampling, of course, and it could be proved not only by the testing the ADCs in the time domain (best sinewave curve fit test) but also by the testing in the frequency domain (DFT/FFT test). The short-time instability of the testing signal results in decrease of the quality of the testing procedure, which causes worsening of the measured parameters of the tested ADCs.

2. BEST SINEWAVE CURVE FIT METHOD

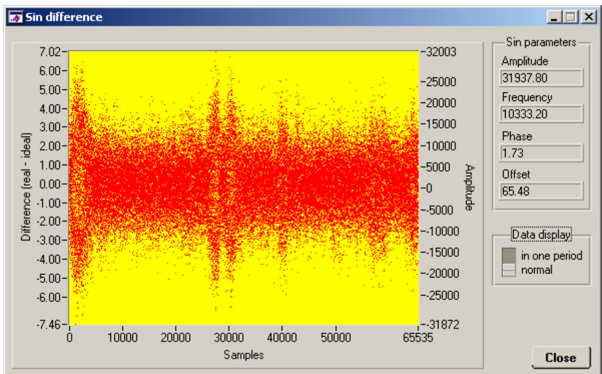
Provided a very good short-time stability of the gain and the sampling frequency of the tested AD module, the best sinewave curve fit test can be used for the evaluation of the short-time instability of a testing signal. This method fits the ideal sinus function to the measured data, which corresponds to the real waveform including all instabilities. Then it is easy to count residuals (differences between measured and fitted waveforms) and to observe their time dependence, which corresponds to the instability of the used generator. The transportable reference AD device designed and developed in FEE CTU for a comparison of ADC testing systems [1] was used for this purpose. The typical results are shown in the Fig. 1. There is no visible instability in case of



a) Generator DS 360

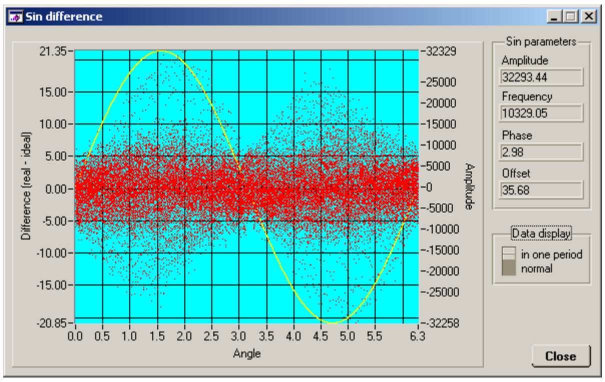


b) Generator KH 4400A

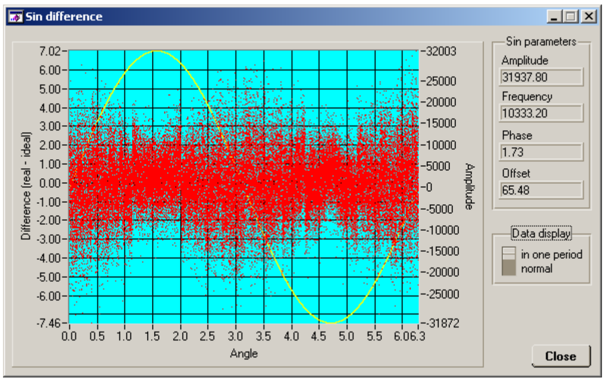


c) Generator R&S UDP

Fig. 1. The value of residuals of all samples

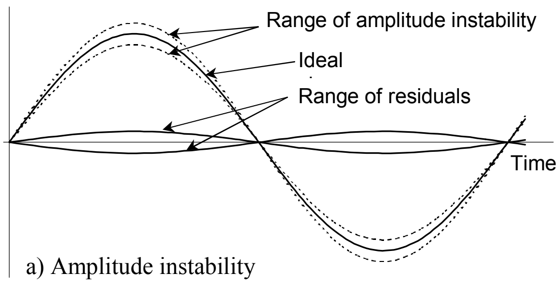


a) Generator KH 4400A

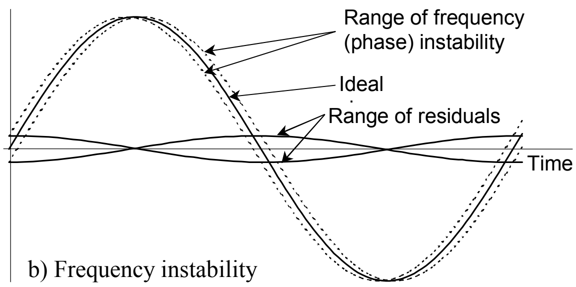


b) Generator R&S UDP

Fig. 2. The residuals of all samples recalculated to one period of the testing signal



a) Amplitude instability

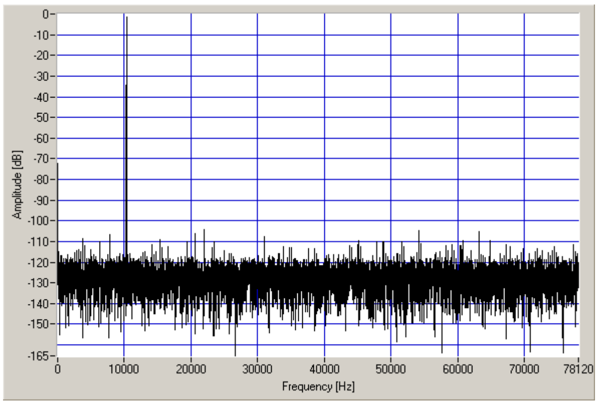


b) Frequency instability

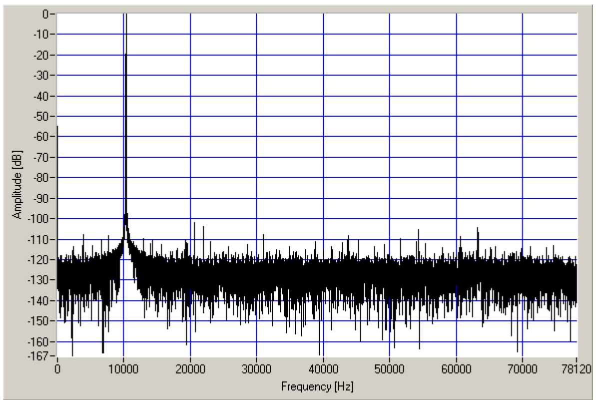
Fig. 3. The course of residuals in dependence on the type of the generator instability

the Fig. 1a. The results in the Fig. 1b and 1c indicate an instability, but it is not possible to evaluate the type of it (either amplitude or frequency). It enables the representation displayed in the Fig. 2, where the residuals of all samples are recalculated and displayed to one period of the testing signal.

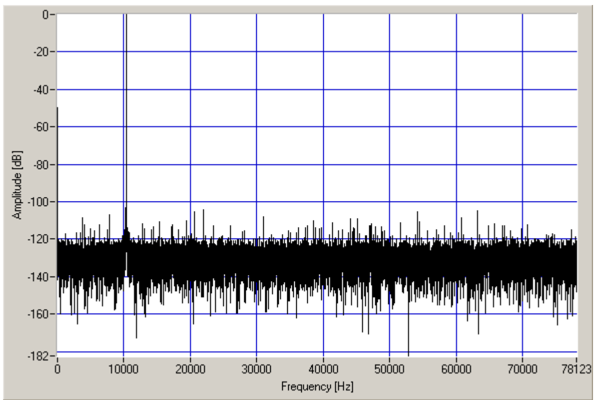
The position of the maximal residuals depends on the type of the instability (see Fig. 3). If the residuals achieve their maximums in the location of the peak values of the testing signal, the amplitude instability is detected (Fig. 3a). The maximums of residuals near zero crossings of the testing signal indicate the frequency instability (Fig. 3b). Following from the comparison of the Fig. 2 and 3, the residuals displayed in the Fig. 2a correspond to the signal with the amplitude instability, whereas the residuals displayed in the Fig. 2b to the frequency instability.



a) Generator DS 360



b) Generator KH 4400A



c) Generator R&S UDP

Fig. 4. Frequency spectrum

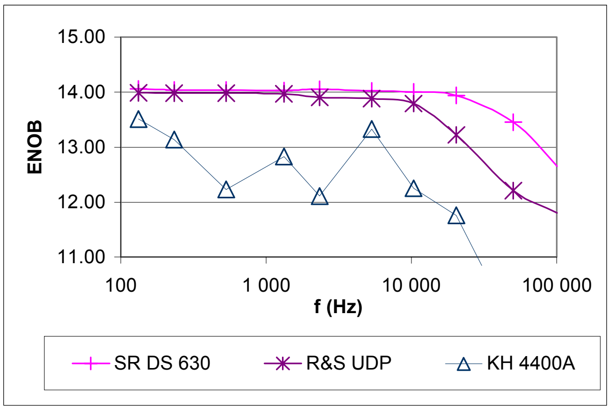
3. FFT METHOD

Significant short-time instabilities are also visible in the frequency spectrum of the testing signal. It appears like a slight deviation from the fundamental component (see Fig. 4b for the amplitude instability and Fig. 4c for the frequency instability). A less significant instability is hardly noticeable; though it can influence the test results.

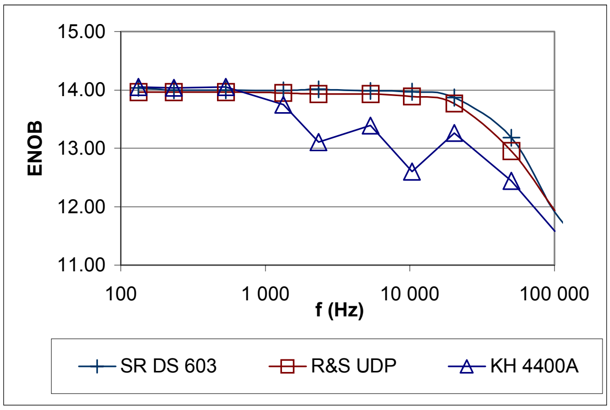
4. HOW SHORT-TIME INSTABILITIES INFLUENCE THE EFFECTIVE NUMBER OF BITS EVALUATION

The short-time instabilities influence the credibility of results of both methods used for the effective number of bits (*ENOB*) evaluation. The random character of the arising errors causes the great dispersion of results. The irregularities in the graphs published in the Fig. 5 and 6 are an outgrowth of it.

The best sinewave curve fit test is more sensitive to the short-time instabilities (compare the Fig. 5a and 5b). A significant error can cause even such a small short-time instability, which is not visible in the frequency spectrum (compare the Fig. 5a and 4c).



a) best sinewave curve fit test

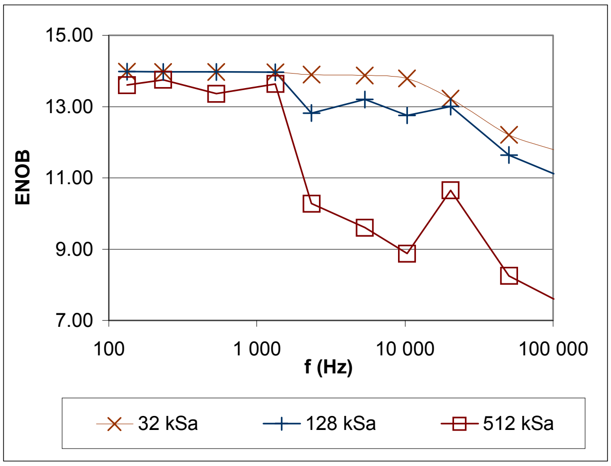


b) FFT test (B&H 7 term window)

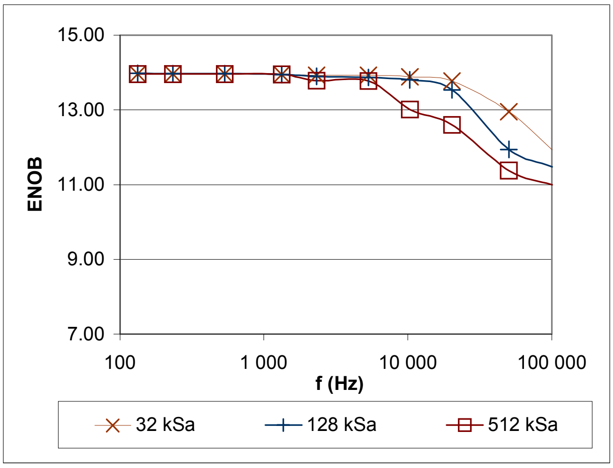
Fig. 5. Influence of short-time instabilities in the ENOB evaluation (32 kSa were processed)

Concerning the FFT method, it partially suppresses both short-time instabilities. It is an effect of the used algorithms of the ENOB evaluation, where several bins around the fundamental component are eliminated because of windowing (the width of the window-lap in the frequency domain). Only a greater instability influences results by using this method (Fig. 5b, generator KH 4400A).

Using the both methods, the more samples are processed, the more both instabilities could be proved. This is visible especially in case of the best sinewave curve fit test method (Fig. 6a). FFT graphs are essentially smoother because the FFT method eliminates the influence of the instabilities (Fig. 6b).



a) best sinewave curve fit test



b) FFT test (B&H 7 term window)

Fig. 6. Influence of number of samples in the ENOB evaluation if a short-time instability is present (Generator R&S UDP)

5. CONCLUSION

The described method, which utilises the best sinewave curve fit test, enables a good detection of short time instabilities of a sinusoidal signal. The type of the instability can be determined from the position of the maximal residuals. It is more sensitive then the evaluation of the short-time frequency instability using frequency spectrum. Concerning the short-time amplitude instability, it is also heavily traceable using classical methods of measurement (the RMS value measurement etc.).

The short-time instability can be one of the reasons of a possible difference between the results of application of the FFT test and the best sinewave curve fit test. The results for one input signal frequency (2333 Hz) and two different numbers of samples are published in Table I as an example (32 kSa correspond to the sampling of 470 periods and to the time about 200 ms). The *ENOB* of the transportable reference AD device was measured using different generators and different numbers of samples applying both methods for the data processing.

Table I. The determined value of ENOB of the transportable reference AD device (the input signal frequency 2333 Hz)

	SR DS 360		KH4400	R&S UDP	
	32 kSa	128 kSa	32 kSa	32 kSa	128 kSa
FFT	14.0	14.0	13.1	13.9	13.9
sine fit	14.0	14.0	12.1	13.9	12.8
difference	0.0	0.0	1.0	0.0	1.1

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