System for Testing Analog-to-Digital Converters

Daniel Belega
Department of Measurements and Optical Electronics,
Faculty of Electronics and Telecommunications,
University "Politehnica" of Timisoara, Bv. V. Parvan Nr. 2, 1900 Timisoara, Romania,
Phone/Fax: ++40-56-20 45 66, E-mail: belega@meo.ee.utt.ro

Summary – This paper presents a system named **ADC TEST** that estimates the static and dynamic parameters of an analog-to-digital converter according to the definitions given in IEEE Standard 1241. One shows the available output graphical pages with theirs information and facilities in a practical testing application.
Keywords – estimation of ADC static and dynamic parameters, testing of ADCs by interpolated fast Fourier transform, windowing.

INTRODUCTION

The precision of a digitizing instrument is established, in principal, by the performances of the analog-to-digital converter (ADC) used. For this reason, an accurate error characterization of ADCs is becoming a primary issue in modern measurement technology. Different ADCs test systems have been implemented [1], [2], [3]. In general the hardware setup of such test system requires signal generators, an ADC evaluation board, a digital capture and a controller or host computer. The controller or host computer contains the software which implements different test methods.
In this paper is presented a system for testing the ADCs named **ADC TEST**. This system performs the characterization of ADCs according to IEEE Standard 1241 [3].

PRESENTATION OF THE ADC TEST

ADC TEST is a complex system with the following key features:
• Maximum record length of 4096 samples.
• Maximum sampling frequency of 20 MHz.
• Control of the signal generators via IEEE-488 bus.
• The software used for testing the ADCs is easy to use; it interacts with the user through graphic interfaces driven by mouse.
• Designed for testing the ADCs when the sampling frequency is noncoherent with the sinewave input frequency [3] because this is the most encountered situation in practical applications of ADCs. However, **ADC TEST** permits, also, the testing of ADCs when these frequencies are coherent.
• Four methods for dynamic testing:
  - testing by spectral analysis in "single-tone" mode,
  - testing by spectral analysis in "dual-tone" mode,
  - testing by power spectral density,
  - testing by interpolated fast Fourier (IFFT) transform [4].
• Statistically testing by histogram method.
• Characterization of the acquisition process.
• For each test method several output graphical pages are available, which provide a large amount of information concerning the ADC performances.
• Comparison of the results obtained with the ones given in the ADC data sheet, with the indication "go no go".
• Saving in ASCII format data files of the parameters that characterize the acquisition process and of the ADC parameter estimates.
• Possibility to process also data files obtained by simulation or by means of other acquisition systems.

ADCs characterization by spectral analysis in both modes is performed by the algorithm presented in [5]. This algorithm leads to high precision ADC dynamic parameter estimates.
The power spectral density is estimated by Welch method [6]. This method leads to a more accurate and less biased result than that obtained using a single fast Fourier transform (FFT).
The testing of ADCs by IFFT transform is performed by the algorithm presented in [7].
ADC TEST estimates the key dynamic parameters of an ADC: signal to noise and distortion ratio (SINAD), effective number of bits (ENOB), total harmonic distortion (THD), signal to non harmonic ratio (SNHR), spurious free dynamic range (SFDR) and intermodulation distortion (IMD). Also, **ADC TEST** estimates the most important static parameters of an ADC: differential nonlinearity (DNL), integral nonlinearity (INL), offset and gain errors. In addition, with the histogram method, using the algorithm proposed in [8], the effective number of bits associated with the deterministic behavior of the ADC under test is estimated.
The acquisition process is characterized by "Modulo Time Plot" method [9].
The block diagram of the **ADC TEST** is presented in Fig. 1.

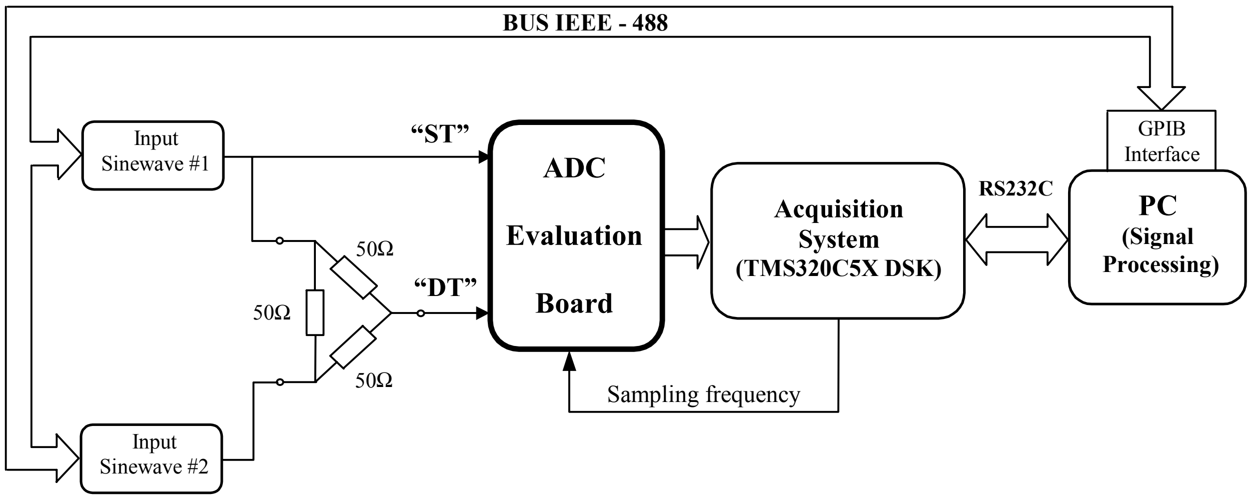


Fig. 1. Block diagram of the **ADC TEST**.

The acquisition system is based on the TMS320C5X DSK board [10] containing a TMS320C50 16-bit fixed-point digital signal processor. Using this acquisition system it is possible to test ADCs with a moderately high resolution (up to 10 bits) and a maximum sampling frequency of 20 MHz.

The program for testing the ADCs was written in MATLAB 4. Recently, in [11] is presented a very efficient and complex program written, also, in MATLAB for testing the ADCs according to IEEE Standard 1241. By comparison with this program the program used by **ADC TEST** is focus on the testing of ADCs when the sampling process is noncoherent with the sinewave input and implements only the sinewave test methods. The program used by **ADC TEST** provides additional information which are very useful for the user such as: visual localization and the values of the first ten harmonic distortions in the "single-tone" mode, the values of the intermodulation components until the fourth-order in "dual-tone" mode, comparison of the performances obtained with the ones given in the ADC data sheet.

EXPERIMENTAL RESULTS

The results obtained with **ADC TEST** in an ADC practical testing application are presented. The ADC tested was TLC0820 [12], which is a high speed 8-bit unipolar half-flash converter type, realized in LinCMOS technology, with a minimum access and conversion time in the most rapid write-read mode of 1.18 µs.

The sinewave generator employed for testing of TLC0820 was the programmable function generator HM8130 [13]. The dynamic performances of the sinewaves used, obtained by testing, allow for an accurate dynamic evaluation of an 8-bit ADC.

The acquisition programs were written in C and in assembly language of TMS320C50.

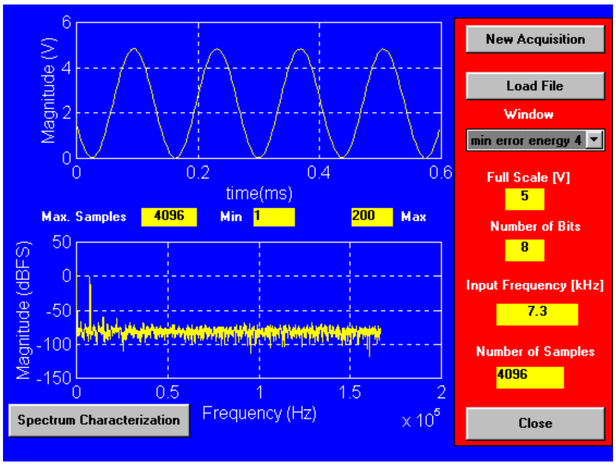
Fig. 2 presents the output graphical pages available after testing by spectral analysis in "single-tone" mode with the algorithm presented in [5] ("DFT Method" selected). When "Interpolated FFT" is selected the THD and SFDR are estimated by IFFT transform [4] and the others are estimated by the algorithm presented in [5]. The windows were chosen by means of the window's performance parameter presented in [14].

Fig. 3 presents some of the output graphical pages available after testing by IFFT transform. The upper graphs of Fig. 3(a) present the "Modulo Time Plots" of the best sine fit corresponding to the ADC output signal and of the residual error [7]. In the bottom graph of Fig. 3(a) the power spectral distribution function (PSDF) of the residual error is plotted. This plot clearly outlines the distortions of the output signal [15].

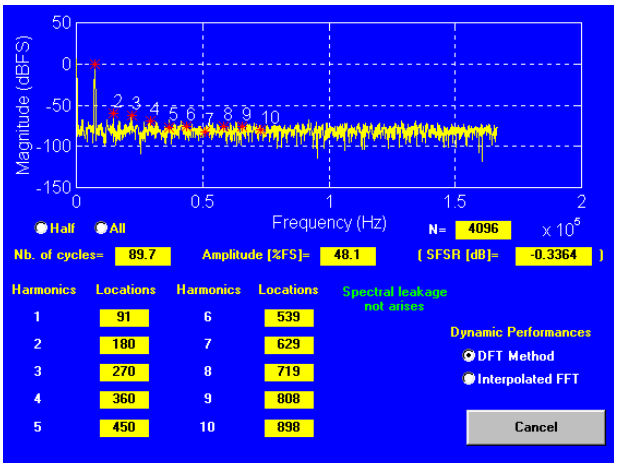
In Fig. 4 some of the output graphical pages available after the testing by histogram method are shown.

CONCLUSION

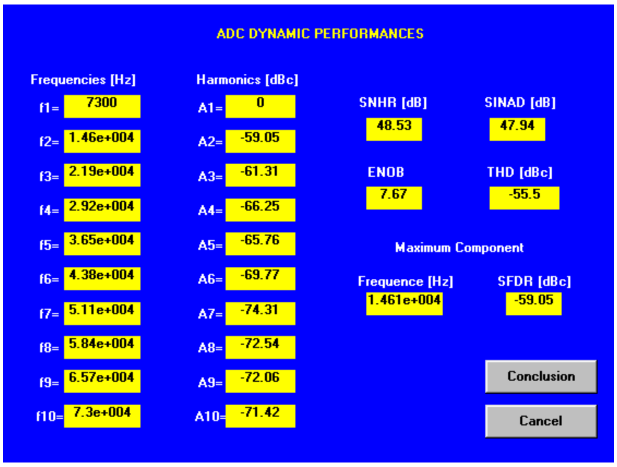
ADC TEST is a very useful and highly precise tool for testing of ADCs as specified in IEEE Standard 1241. It is easy to use and provides a large amount of information and output graphical pages concerning the ADC performances. Future work will focus on improving the performances of **ADC TEST** by replacing the acquisition system with another more efficient and by introducing new facilities, like for example the characterization of the dynamic parameters as a function of input frequency.



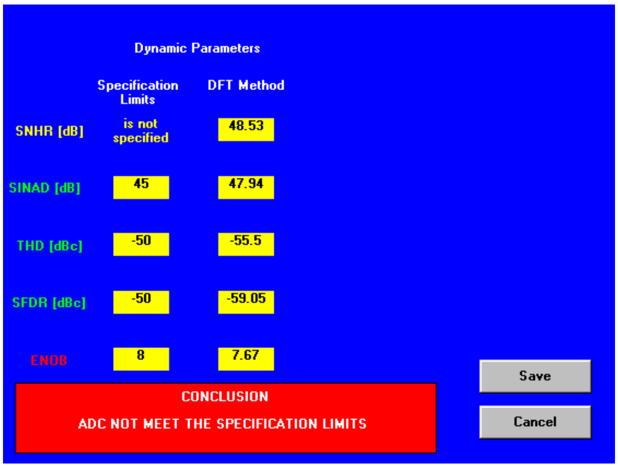
(a)



(b)

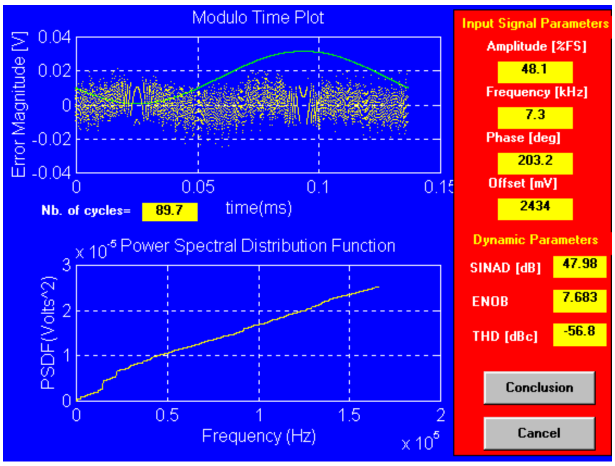


(c)

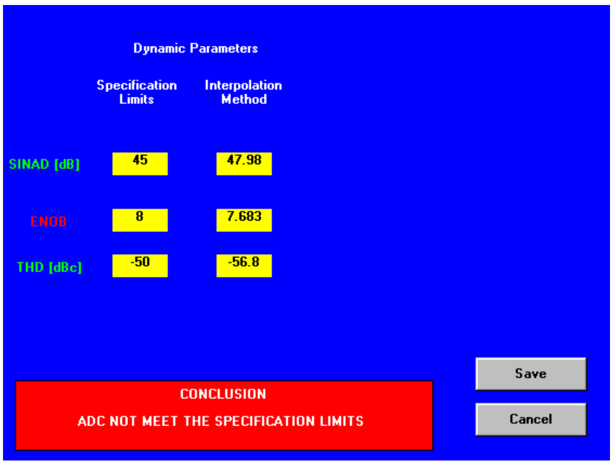


(d)

Fig. 2. The output graphical pages available after testing by spectral analysis in “single-tone” mode.

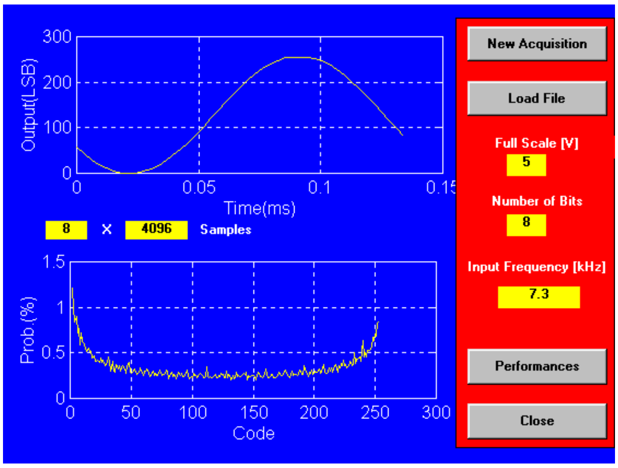


(a)

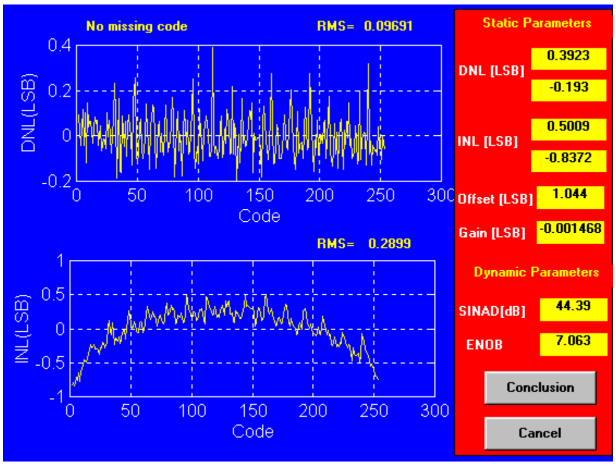


(b)

Fig. 3. Some of the output graphical pages available after testing by IFFT method.



(a)



(b)

Fig. 4. Some of the output graphical pages available after testing by histogram method.

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