A PLATFORM FOR MICRO-CONTROLLER CHARACTERIZATION

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Abstract − The characterization of the micro-controllers involves the characterization of its peripheral devices, mainly the ADCs, the PWMs, the timer signals, sometimes the DACs. A testing platform has been realized, with reference to the ST430 micro-controller. It consists of a board and some programmable instruments connected to a PC, on which the implemented software can run. The user can make the choice of the test to be performed, can carry out the chosen test and can analyze and store the results. The static ADC characterization has been taken into account in this work and some results obtained by using this platform are presented.

Keywords: Characterization, micro-controllers, ADCs.

1. INTRODUCTION

Particular attention has been devoted by the researchers to the characterization of the ADC, and a standard for the terminology and for the test methods has been developed [1]. ADC modeling and testing has been widely investigated, with different aims [2, 3]:
- to optimizing the test procedure;
- to develop an accurate model which takes into account non-linearities;
- to minimize the test effort;
- to on-line test the validity of the model.

Measurement procedures and methods for static and quasi-static test of ADCs have been implemented mainly for reducing the experimental burden [4, 5].

The FFT test has been used in order to derive the integral non-linearity of ADCs, because in some cases it is faster than histogram test and static non-linearity test [6].

ADC testing with IEEE standard 1241-2001 relies on frequency domain techniques, which can produce a robust characterization of the ADC. Analysis based on these techniques can yield the various testing parameters [7].

The characterization of a micro-controller involves the characterization of its peripheral devices, mainly the ADCs, the PWMs, the timer signals, sometimes the DACs.

In order to simplify the procedures to be used for the characterization of the micro-controllers, a testing platform has been realized, with reference to the ST430 micro-controller.

The implemented testing procedures include the one needed for the static characterization of the ADC, as a peripheral device of the micro-controller.

The main features of the platform are described in the next section, while some results of the static characterization of the ADCs of both the ST430 and the ST440 micro-controllers are presented in the third section.

2. DEVELOPED TESTING PLATFORM

The testing system consists of a board and some programmable instruments connected to a PC, on which the implemented software can run. Each pin of the device under test can be properly connected to instrumentation using a testing board in which device is inserted. Also the voltage supply can be properly connected to the correct pins.

An interface between the serial port of the device and the serial port of the PC has been used to transfer the data from the micro-controller to the PC.

A function generator, an oscilloscope, a PC and a dc power supply are used: they are interconnected by the standard IEEE 488. A DAQ card has also been used for the characterization of the ADC and for the generation of pulses to synchronize the software procedures with the micro-controller ones. A flexible software has been implemented; an example of the interface presented on the monitor of the PC is shown in fig. 1.

The user is required to choose the clock frequency and the measurement instruments. Each test requires an assembler routine, so a specific function has been implemented to perform the download of the assembler code on the device under test.
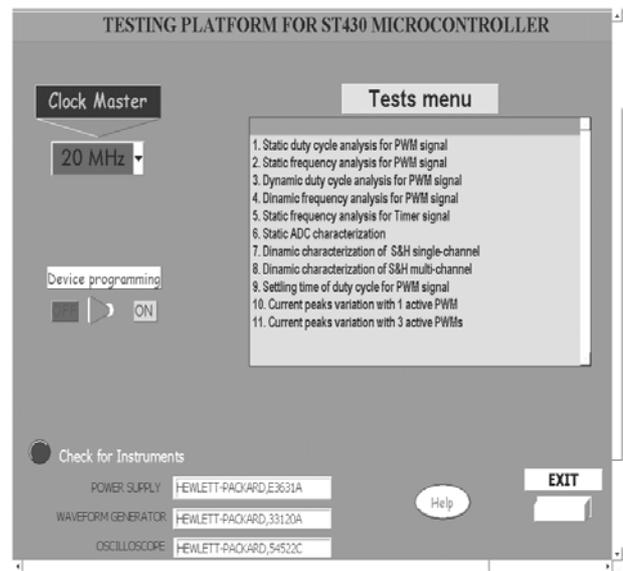

Fig 1. The realized testing platform.

The menu of the developed tests is shown as well. The software stores the data in a suitable way: indeed, the management of the data files is performed carefully.

An on-line help has been implemented in order to simplify the testing operation. It shows the board and the hardware connections.

Particular attention has been devoted to the implementation of the software for the presentation of the results. The results obtained in a single test are directly shown on the display. Moreover, other choices can be made on the files already stored.

In order to emphasize some characteristics of the realized platform, in the next section the results of the test performed on the ADCs of both the ST52x430 and the ST440 micro-controllers are presented.

3. STATIC CHARACTERIZATION OF THE ADC

The main purpose of the realized system is the characterization of micro-controllers: thus, only the static characterization of the ADC as a component of the micro-controller has been implemented. Therefore, as an example, only the synthetic results obtained by using the platform are presented here. The structure of this peripheral device under test is shown in fig. 2.

The goal of the developed tool is to assess the linearity, the offset and the effective bit number.

These pieces of information can be obtained from the characteristic curve of ADC under test. This characteristic has been acquired by continuously
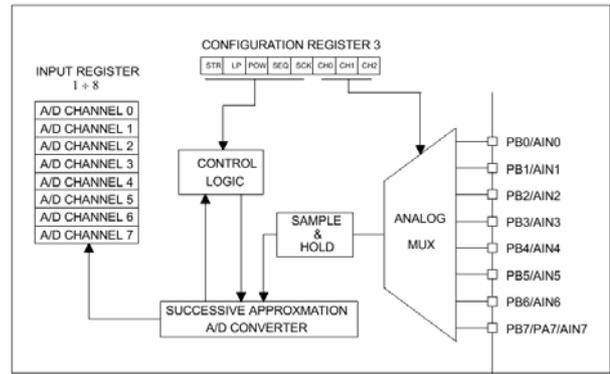

Fig. 2. The structure of the ADC under test.

converting a reference voltage generated by 12 bit DAC from the DAQ card also used in this platform. Since ST430 is an 8 bit micro-controller the DAC is accurate enough.

The software running on the PC drives the DAQ to generate ramp voltages V_{DAQ}, in the range from 0 to V_{FS} with resolution lower then 0.5 LSB. For each value of the generated voltage a great number of samples (sometimes over one thousand) are acquired by ADC. The converted voltages V_{ADC} are transmitted to the PC through the serial communication port. After collecting all data the software shows directly the characteristic V_{ADC} *vs* V_{DAQ} which carries out information about offset and linearity. As it can see in fig. 3, the software also gives the histogram of the residuals between V_{ADC} and: moreover, it calculates the mean value, the standard deviation and the variance.
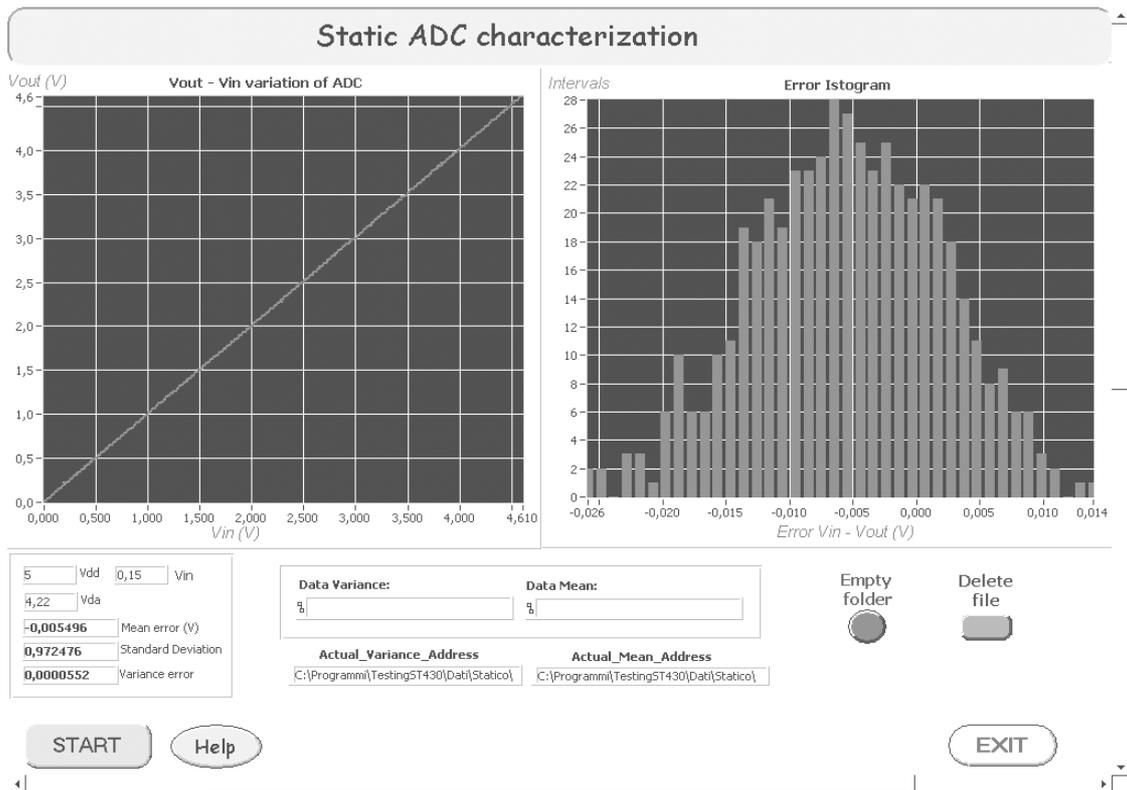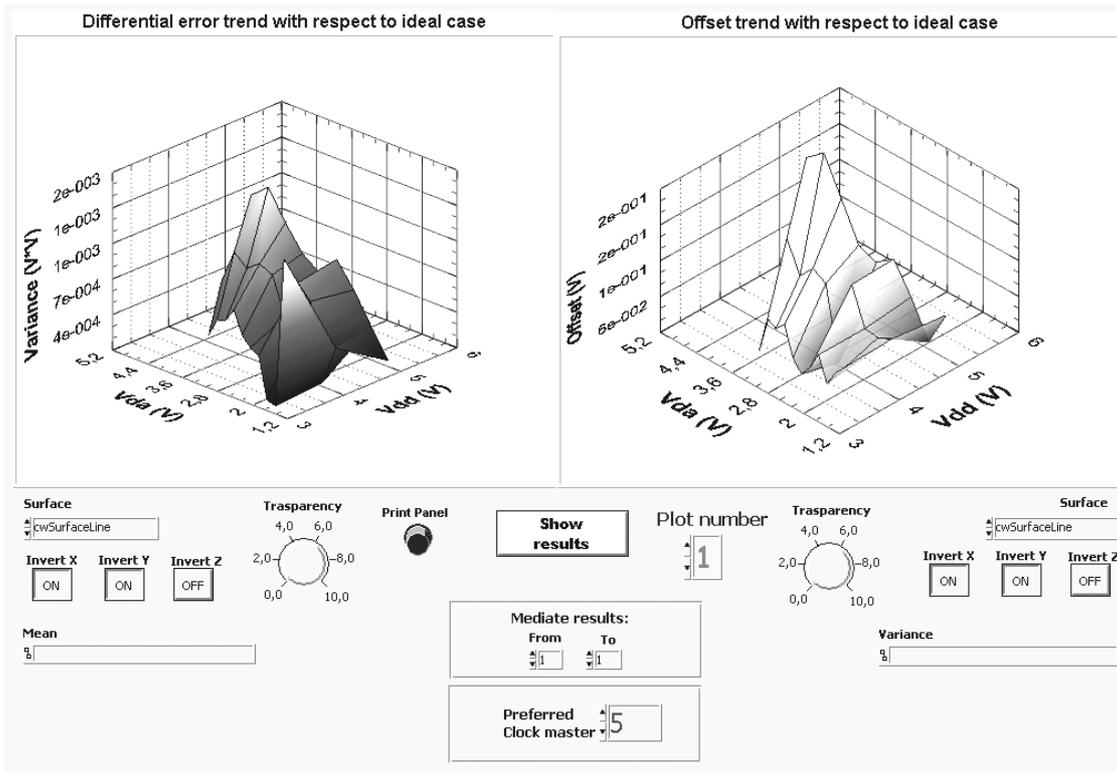

Fig. 3. Characteristic of the ADC under test.

Fig. 4. Parametric graph of ADCs offset and variance.

The ADC of ST430 micro-controller has a separate supplying circuit for ADC block to reduce noise effect coming from the power supply. Let's indicate V_{DD} and V_{DA} the voltage supply of micro-controller and the voltage supply of ADC circuit, respectively.

The characterization of the ADC for various arrangements of V_{DA} and V_{DD} was exploited, in order to assess configurations allowing for optimal performances of the device. The obtained results are shown in fig. 4.

Device interacting with the ADC can produce effects reducing the performance of the converter. As an example the sample and hold block produces a limitation in the dynamics of the ADC.
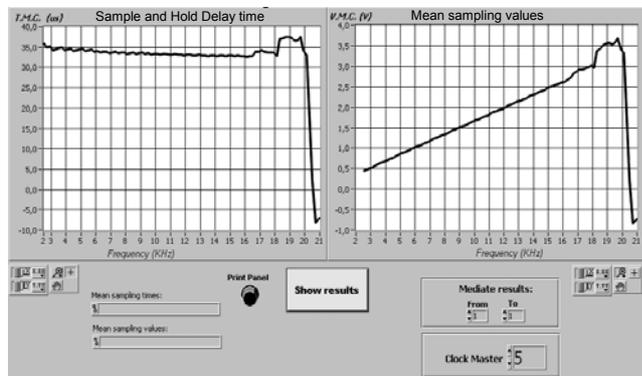

Fig. 5. Delay time introduced by the Sample and Hold device as a function of the ramp test signal frequency @ 5 MHz clock.

To investigate this phenomenon the following test was accomplished. An external comparator was used which compares a ramp signal and a reference voltage and generates the start event for the ADC conversion. The stop event is generated by micro-controller at end of conversion. Results of this test are reported in fig. 5, which shows the delay time between the starting event (given by the comparator) and the conversion initial time which depends on the Sample and Hold dynamics (estimated by the converted ramp level).

In order to exploit the flexibility of the developed tool, the static characterization of another fuzzy micro-controller, ST440, has been also performed. This micro-controller is not provided with internal ADC device. However, it includes an analog comparator, three current generators, a band gap reference voltage and a configurable counter.

The user can easily choose a value for the current generator and generate a ramp by including an external capacitor. By using both the comparator and the counter a single ramp ADC can be easily implemented.

A large number of parameters must be taken into account for the investigated micro-controller: capacitance, number of bits, current level. In order to assess the behavior of the device as a function of the parameters above mentioned, several tests were performed which are shown in fig. 6. In particular, standard deviation, offset and slope have been investigated, which assume the same meaning already discussed in the case of the previous device characterization.
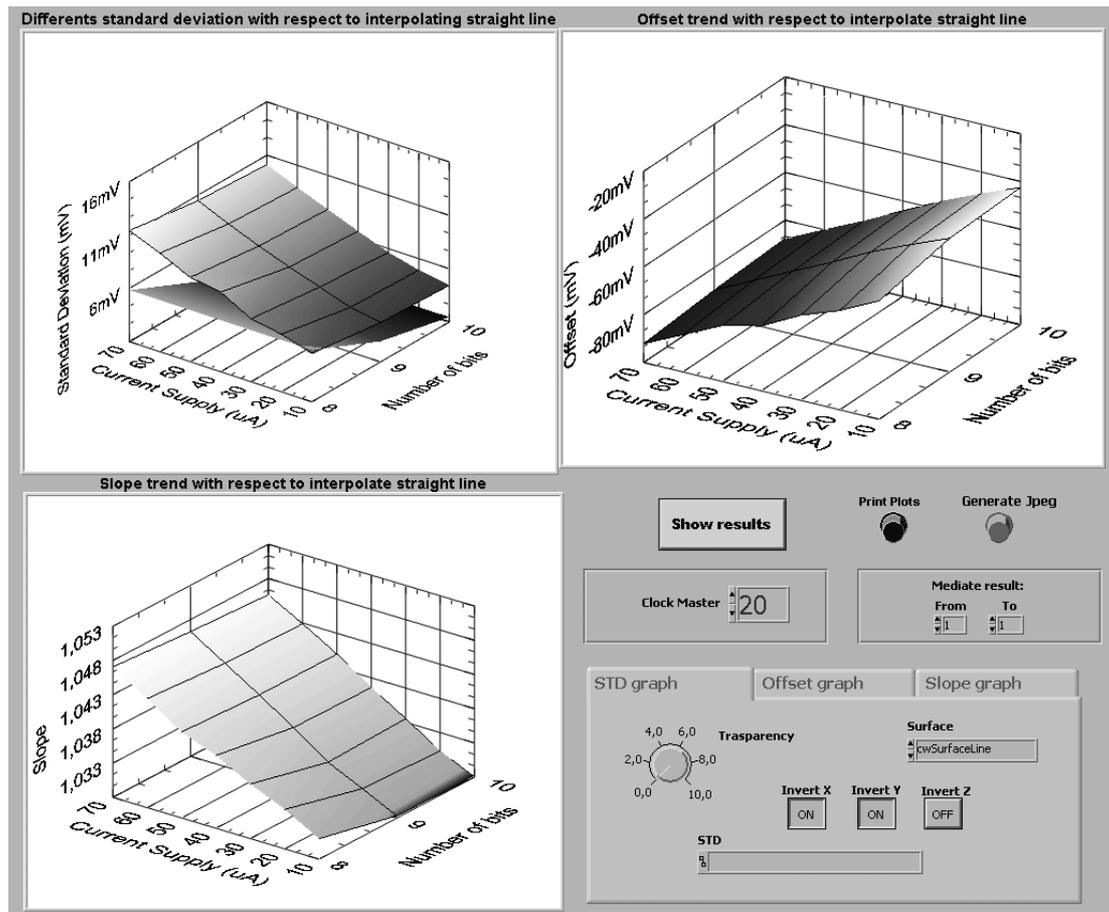
Fig. 6. Results of a static characterization of single ramp ADC.

4. CONCLUSIONS

In this work, a platform for the characterization of micro-controllers has been presented along with two examples of application. To drive the various pieces of the adopted hardware a suitable software was implemented. In particular, the system allows the user carrying out the static characterization of the ADC.

As an example, the ADCs of two micro-controllers have been tested and the obtained results have been synthetically shown.

Flexibility in the developed architecture allows for a easy re-arrangement of both the hardware and the software, to make it compatible with other micro-controllers.

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