

DA AND DA CONVERTERS DEMONSTRATION BOARD FOR EDUCATION

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ABSTRACT

This paper describes the design and the construction of the demonstration board. This board is used to demonstrate function and behavior of the AD and DA converters. It allows display and explores typical errors of converters. Measured values are showed on the PC and the education program helps students to understand function of converters. The demonstration board uses USB to connect to the PC.

1. INTRODUCTION

Because of, the world around us is analog we always need to execute analog value by digital logic convert analog value to the digital number and/or back digital number to the analog value. This conversion provides AD and DA converters. Due to, the part of the common knowledge of any electro engineers should be know “How AD and DA converters works”. The laboratory task oriented to acquaint students with behavior and errors of the converters were solved.

2. SYSTEM TOPOLOGY

The demonstration board is controlled over the microcontroller ATMEGA16. The microcontroller provides control with 8-bits ADC and DAC and communication with PC via USB. Besides, thanks to the integrated 10-bits approximation ADC the microcontroller is able to check transfer characteristic of the DAC.

2.1. BLOCK SCHEME

The block scheme of the designed measuring system can be observed in Fig. 1. The demonstration board is not equipped with visual display unit. Due to, the communication with PC is crucial. The special utility receives data from the demonstration board and next it shows measured values on the PC's monitor. The block scheme can be separated to two parts. To the circuitry provides control of the converters and measuring and to the circuitry for communication with PC thru USB. Because of the students are not engineers, some extended safety arrangement must be done like as clamp diodes at the input or separating operational amplifier.

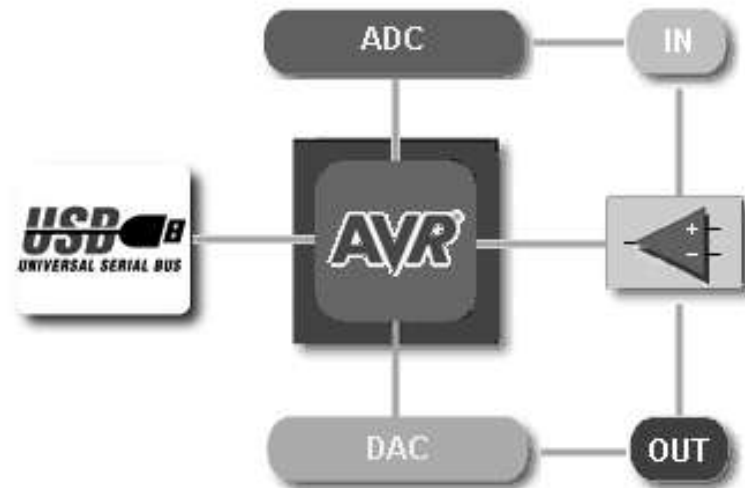


Fig. 1: The block scheme of the demonstration board

2.2. LABORATORY TASK

The demonstration board is directly supplied over the communication interface USB. The BNC connector is used for input and output. The laboratory tasks are conceived for using the demonstration board, oscilloscope and frequency generator only. The photo of the laboratory task formation is shown in Fig. 2.

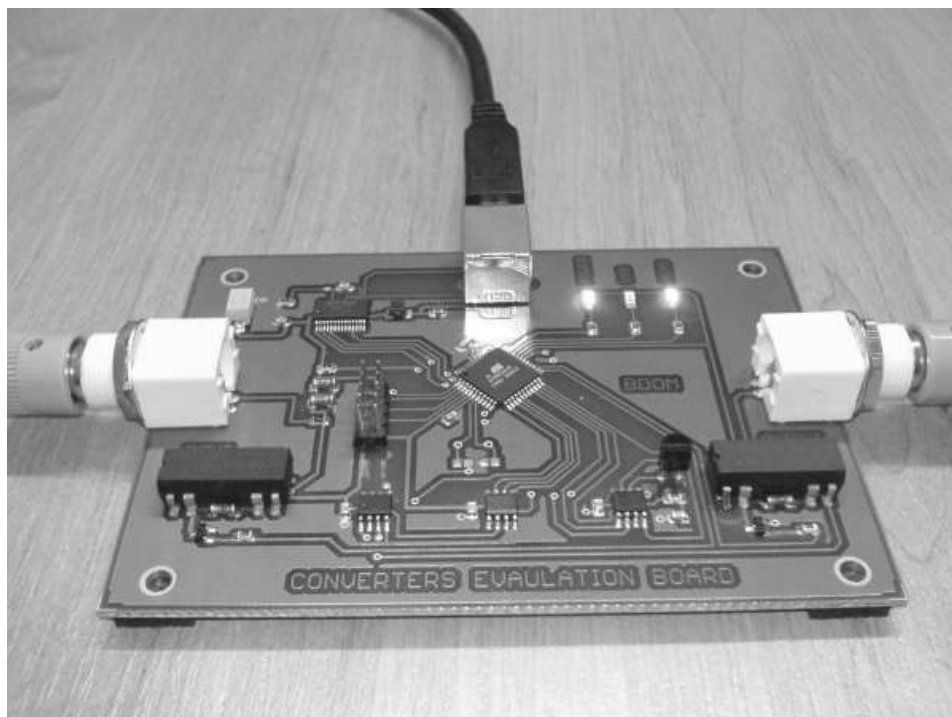


Fig. 2: Formation of the proposed laboratory task

3. CONVERTERS

The 8-bits converters were advisedly used because of the quantization errors are very prominent. It allows easy observe form of the integral and differential error of the DAC's output and of the ADC's input characteristics. But if we want measure output characteristic of the 8-bit DA the AD converter with better resolution is needed. We used internal 10-bits AD converter of the microcontroller ATMEGA88. Whereas errors and imperfections are desirable in DA converter to show it to the students, but the measuring 10-bits AD converter would be without errors. Due to, every evaluation board, respectively AD converter integrated in microcontroller is calibrated. The calibration values are stored in EEPROM which is integrated in microcontroller too. Part of the demonstration board is analog comparator which can be used together with DAC to create approximation ADC. Since the approximation register is amended microcontroller some types of the approximation can be examined.

4. SOFTWARE PACKAGE FOR PC

The special education program utility was programmed. The program controls USB communication with demonstration board and students are interactive taught "how converters works." After self-detection of the demonstration board, program generates identification number of the laboratory task. The identification number consists of the time, date and random number. The time and date is suitably coded in to the identification number. This arrangement would prevent from copying measured data between students because some specific errors are changed.

The second part of the software package is decoder of the identification number. This program "DeInN" provides very simple check correctness of the students measured data processed in their protocols.

The third part of the software package is small program serves to the testing students of their knowledge about converters. The testing program loads data from external files. This enables changing test questions or their random generation for tests.

5. COMMUNICATION PROTOCOL

For communication between PC and evaluation board via USB the special communication protocol was proposed. The simple suite of commands is used for communication. It saves size of the transmitted or/and received bytes thus helps save microcontroller processing time. For every task only eleven commands are used. Communication is opened by sending number marking command. The command is analyzed and depending on type of the command next data are expected or command is processed and data are sent to the PC. The functions which not sending data confirms their successfully execution by sending confirm code. Confirm code is not unified however depends on processed function. This arrangement enables better communication mistakes suppress.

6. THE MUTUAL CHARACTERISTIC MEASUREMENT

In this laboratory task a mutual characteristic of the used DAC is measured. Whole measurement is fully automatic because input data for converter is generated by PC. The output of the DA converter is led to the input of the microcontroller's AD converter, where

the analog value is digitized again. The very important assumption of this measurement is absolute linearity of the used AD converter with zero offset. The digitized value is consequently sent to the PC by microcontroller. The whole mutual characteristic is drawn by the graphical interface of the designed software. Errors, like as integral nonlinearity, differential nonlinearity, offset, gain error, and quantization step error can be defined. The screen of the mutual characteristic measurement is picked up in Fig. 3.

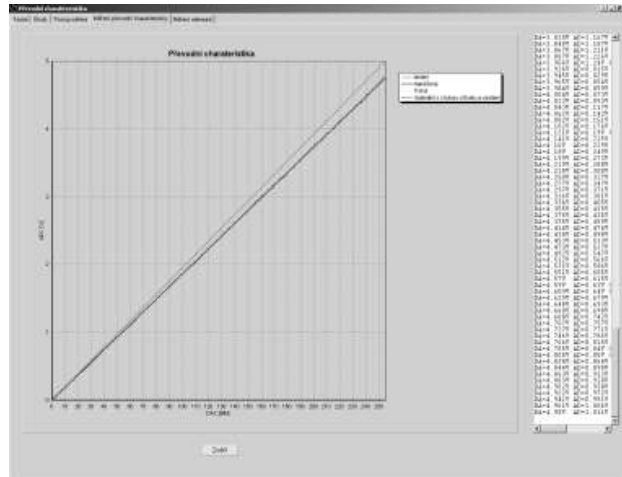


Fig. 3: Mutual characteristic measurement.

7. THE APPROXIMATION AD CONVERTER

Simple 8-bit AD converter can be formed with 8-bit DA converter and analog comparator. The block scheme of the AD converter is picked up in Fig. 6. Because, the approximation register is amended by microcontroller, some types of the approximation method can be examined. Thanks to connection to the PC the timeline of the conversion is presented on the monitor. It enables make better image about conversion process. The internal structure of the approximation converter and every conversion part is showed.

8. QUANTIZATION ERROR MEASUREMENT

Very illustrative example of the quantization error can be observed as a reconstructed analog signal from DA converter. In real it means following. The sinus signal is led to the input of the demonstration board. Here is processed by AD converter. The digital word of the output is used by microcontroller as an input for the DA converter. The reconstructed sinus signal is not as smooth as an original signal. Both of signals, input and output are showed on monitor of the oscilloscope. The difference of these two signals can be showed by using mathematic functions of the oscilloscope. The total size of the quantization error directly depends on the bit resolution of the DA converter. For clearer visibility of the quantization error, evaluation board offer set the effective bit resolution of the DA converter from 8 down to 4 bits.

9. POWER SUPPLY

Thanks to the connection to the USB the external power supply is not needed. Whole power consumption of the evaluation board is provided by USB. Unfortunately, the supplying

voltage is not exactly 5Volts so additional error is presented in each measuring. But in real applications where AD or DA converters are used, the same problem must be solved.

10. CONCLUSION

Presented article describes design and construction of the converters evaluation board for education. Next it describes developed control software, communication protocol between evaluation board and PC and special software for teachers which serve to easy check correctness of the student's measured values. This software is running as an internet application some laboratory tasks were presented too.

ACKNOWLEDGEMENTS

The research has been supported by Czech Ministry of Industry within the frame of the Research Plan MSM0021630503 MICROSYN, by the Czech Grant Agency as the project GD102/03/H105 Modern methods of analysis, design and application of the electronic circuits and especially project FRVŠ-2833.

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