

Virtual System for Generating Analog and Digital Signals

Tsvetozar St. Georgiev¹ and Georgi N. Krastev²

Abstract – The report examines the implementation of a virtual system for generating analog and digital signals. The system consists of hardware module NI USB 6008 and specialized software developed using the programming environment LabVIEW. Conducted experimental studies show that the system can be used successfully to test the efficiency of dynamic systems.

Keywords – Virtual systems, Virtual instrumentation, Signal generation.

I. INTRODUCTION

The rapid development of personal computers in the last 20 years accelerates the changes in the tools for measuring, testing and automation. One of the most important outcomes is the creation of the concept of virtual instruments, which offer many advantages such as increased productivity in developing, higher accuracy and better performance.

The virtual instrument (VI) is a combination of hardware and software elements which under the control of PC has the functionality of the traditional instrument. The virtual instruments consist of an industrial PC or workstation equipped with powerful software, hardware and appropriate drivers. Together all these components perform the functions of traditional instruments. VI represents a fundamental shift from the traditional hardware-oriented systems to instrumental-oriented software using computer power, productivity and opportunities for better visualization. Although PC and integrated circuits are very important in implementation of VI, the computer based software provides the implementation of the concept of VI. While users of traditional tools are limited by decisions made by the manufacturers of the equipment, the VI can meet precise needs of the users.

The signal generators are devices that generate signals with certain characteristics. They are most commonly used for testing different equipment in the process of design or repair. There are different types of signal generators, depending on the type and the supported features of the generated signals. They may be separate devices or those managed by computer.

The report is considered an inexpensive version of the generator of analog and digital signals, built on a module NI USB 6008, a PC and software developed using LabVIEW.

¹Tsvetozar St. Georgiev is with the Department of Computing, University of Ruse, 8 Studentska Str., 7004 Ruse, Bulgaria, E-mail: TGeorgiev@ecs.uni-ruse.bg

²Georgi N. Krastev is with the Department of Computing, University of Ruse, 8 Studentska Str., 7004 Ruse, Bulgaria, E-mail: GKrastev@ecs.uni-ruse.bg

II. ARCHITECTURE OF THE VIRTUAL SYSTEM

A. Main components of the virtual system

The developed virtual system will be a part of a system for automobiles dynamic characteristics investigation. This system includes the following units (Fig.1): a hardware module for generation of signals and for data transfer to personal computer (PC); a PC or Notebook and a virtual instrument for signal generation and data acquisition. The application is developed by programming the NI USB-6008 using LabVIEW and using NI-DAQmx driver software for Windows. A NI-DAQmx virtual channel consists of a physical channel on a DAQ device and the configuration information for this physical channel, such as input range and custom scaling [3].

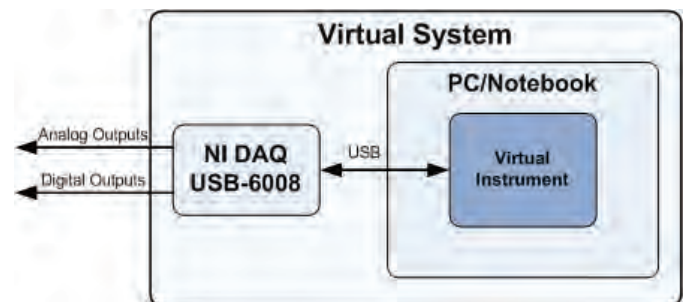


Fig. 1. Architecture of the virtual system

B. Data acquisition (DAQ) hardware module

DAQ hardware module acts as an interface between the computer and the outside world. Devices for data collection may contain analog inputs and outputs, digital inputs and outputs, counters and timers. Information received by them through NI software is analyzed, processed and visualized. DAQ devices are integrated into various hardware platforms, remote desktops, laptops, and industrial computers.

The data acquisition hardware used in this paper is NI USB-6008 multifunction I/O device, which interfaces to the PC through a USB connector. It has 8 differential analog voltage inputs, 2 outputs, 12 channels which can be used as either DI (digital inputs) or DO (digital outputs), and 12-bit resolution [5].

Figure 2 shows the main functional components of the NI USB-6008 [5].

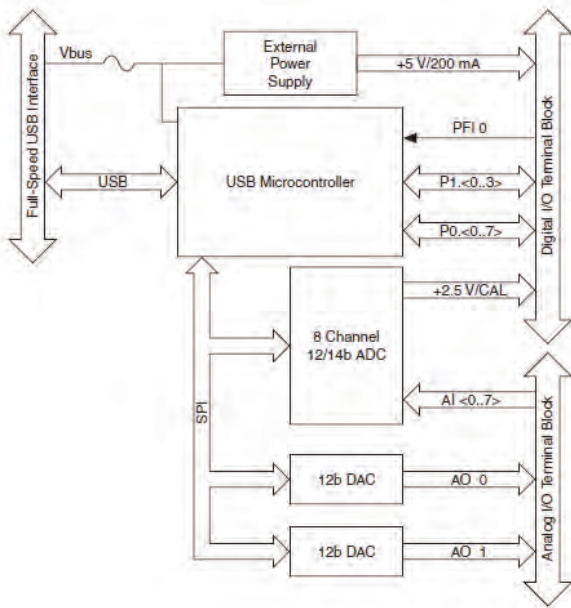


Fig. 2. USB-6008 block diagram [5]

The National Instruments USB-6008 provides basic data acquisition functionality for applications such as simple data logging, portable measurements, and academic lab experiments, as well as abilities for generation analog and digital signal.

C. Virtual instrument

The appropriate environments for development of virtual instruments are LabVIEW, LabVIEW Express, LabWindows/CVI or Measurement Studio of the National Instruments Company, USA.

The LabVIEW environment allows the users to develop test and measurement, data acquisition, instrument control, data logging, and measurement analysis applications. LabVIEW includes a set of VIs that let users to configure, acquire data from, and send data to DAQ devices. Often, one device can perform a variety of functions: analog-to-digital (A/D) conversion, digital-to-analog (D/A) conversion, digital I/O, and counter/timer operation.

The programs which are created by LabVIEW are named virtual instruments because their appearances imitate the real devices [1]. The virtual instruments have an interactive user interface, block diagram of data flow (program code) and icon with connections [2]. VIs can be used as subprograms in other virtual instruments.

The interactive user interface of VI is named Front Panel because it looks like the panel of the physical device. The Front Panel may include buttons, sliders, digital indicators, controls, graphical displays, etc. The user can input information manually by the keyboard and/or import information from data files. The results from the execution of the program code can be seen on the Front Panel. In LabVIEW is used G program language. It has many functions for processing, working with various file formats, analysis, and generation of signals and visualization of data.

The developed virtual instrument is separated on two parts – one for generation of analog signal and other for generation of digital signals. These parts have the following options:

- 1) Part for generation of analog signals (Fig.5 and Fig.6):
 - An ability of the user to select the channel, which led to the generated signal;
 - An ability of the user to select the minimum and maximum output value (in V);
 - An ability of the user to set parameters of the generated signal - output rate (in ms) and the number of points generated per cycle;
 - A possibility to stop the generation of signals (button Stop);
 - An ability of the user to clear the chart from previous values.

The hardware module USB-6008 supports only software-timed update of digital-to-analog converter (DAC). The maximum supported refresh rate is 150 reports per second [4]. Therefore, the output rate can not be less than 6 ms. If this value is reduced, it leads to the resolution of the generated sinusoidal signal, but it reduce the frequency of the signal.

The virtual instrument calculates the approximate frequency of generated signal using the following formula:

$$f_{approx} = \frac{1}{O_R * P_C}, \text{ Hz}$$

where f_{approx} is the approximate frequency of generated signal, O_R is the output rate (ms) and P_C are the points per cycle.

- 2) Part for generation of signals on digital outputs (Fig.3):
 - An ability of the user to set the level (0 or 1) of digital outputs using push buttons (for example from “Digital Out 0” through “Digital Out 5”).
 - An ability of the user to control the execution of the program using the Stop button.
 - An ability of the user to monitor the change of the signal levels by using a special widget Digital Waveform Graph. On this graph with different colors are presented different signals and the level of each signal is indicated with 0 or 1.

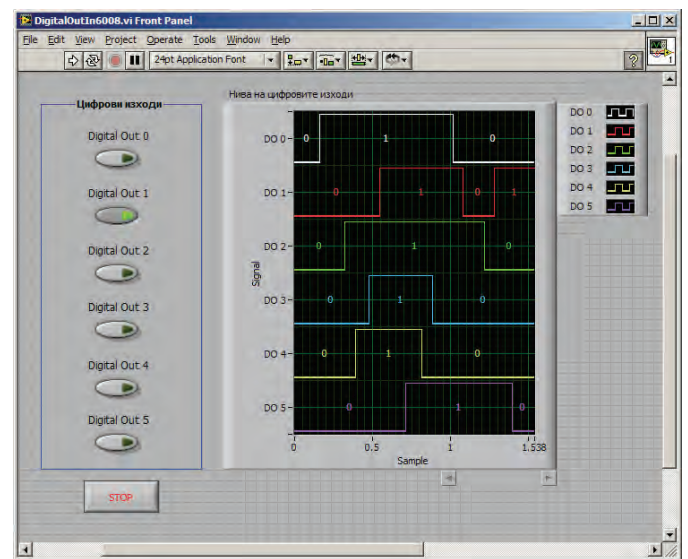


Fig. 3. Front panel of the part for digital signals generation

III. TESTING OF THE SYSTEM

For the purposes of the system testing the following approach was used. The analog output (AO0), where the signal is generated was related to one of the analog inputs (AI0) and six digital outputs were connected to six digital inputs (fig.4).

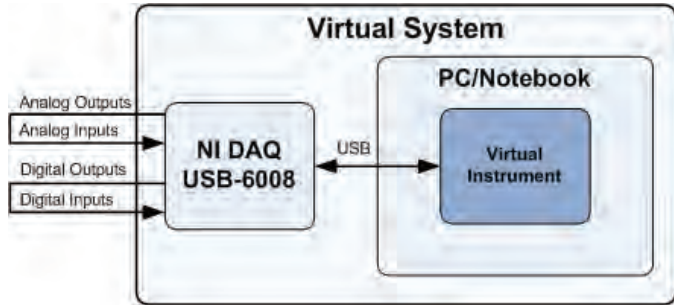


Fig. 4. Architecture for testing the virtual system

The analog part of virtual instrument was modified in such a way to allow selection of input and output channels and to display generated and acquired analog signals. Figure 5 shows the testing results of generation and acquisition of analog signal with an approximate frequency of 33 Hz (the output rate is 6 ms and the number of points per cycle is 5). The maximal value of the generated signal is 5 V and the minimal value is 0 V.

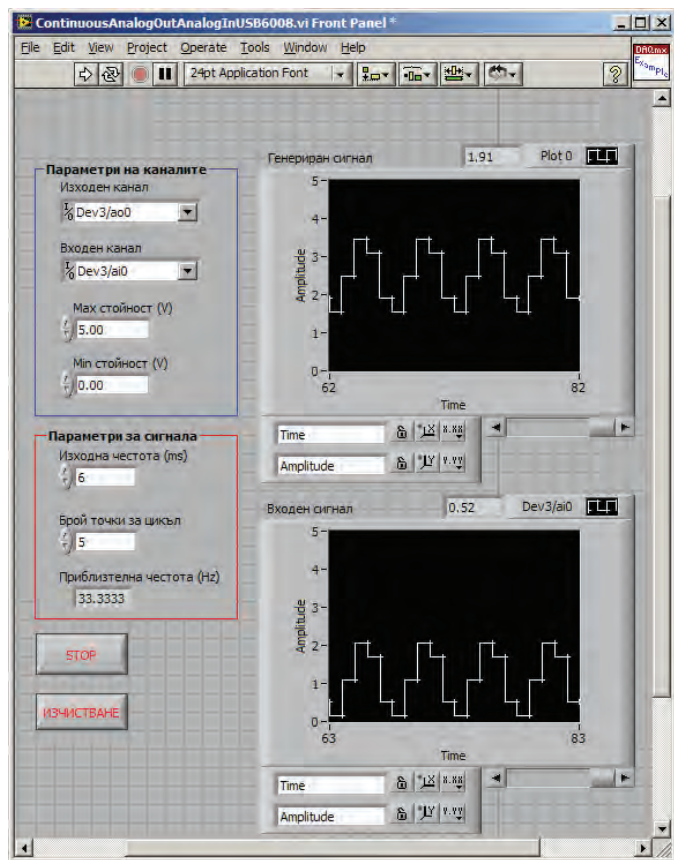


Fig. 5. Generation and acquisition of analog signal with an approximate frequency of 33 Hz

Figure 6 shows the results of generation and acquisition of analog signal with an approximate frequency of 1.67 Hz. In this case the output rate is also 6 ms but the number of points per cycle is 100.

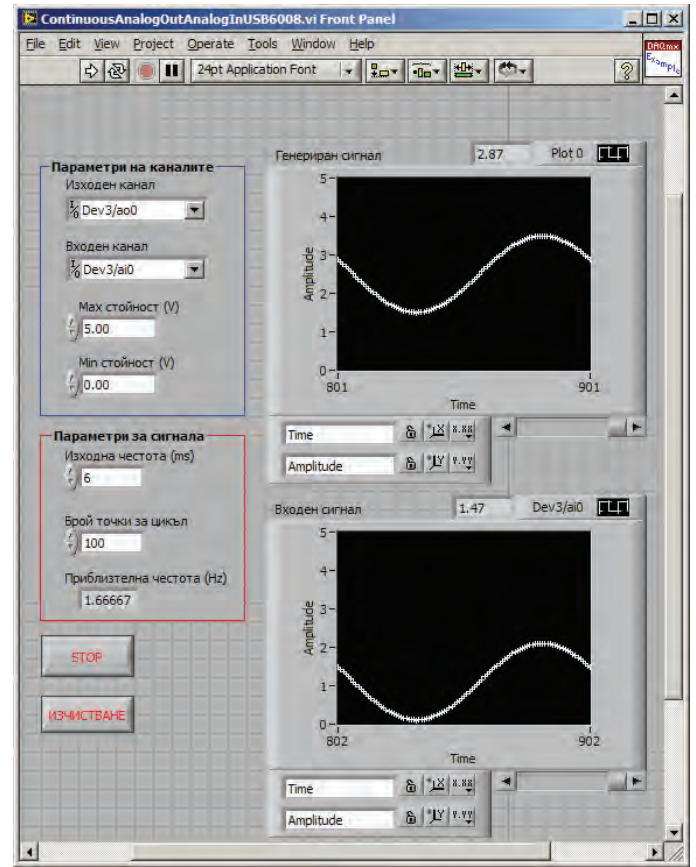


Fig. 6. Generation and acquisition of analog signal with an approximate frequency of 1.67 Hz

It is easily to find that the hardware module USB-6008 is unable to generate analog signals with high frequency and it is suitable for generating signals with a low frequency (up to 15 Hz). The reason for this is the limit of refresh rate which is 150 reports per second.

The digital part of the virtual instrument was modified to display the generated and acquired digital signals. To test the virtual instrument 12 digital input-outputs are divided into two parts of 6 channels. The first part (from P0.0 to P0.5) is initialized as digital outputs, which generate signals. The second part (from P0.6 to P1.3) is initialized as digital inputs. Thus initializing digital outputs are connected to digital inputs using a cable. On the front panel of the virtual instrument are added LEDs which indicate the state change of the inputs. On the front panel a second Digital Waveform Graph element is also added, whereby the user can monitor the change history of the signals.

The test generation and acquisition of six digital signals is given on Fig. 7.

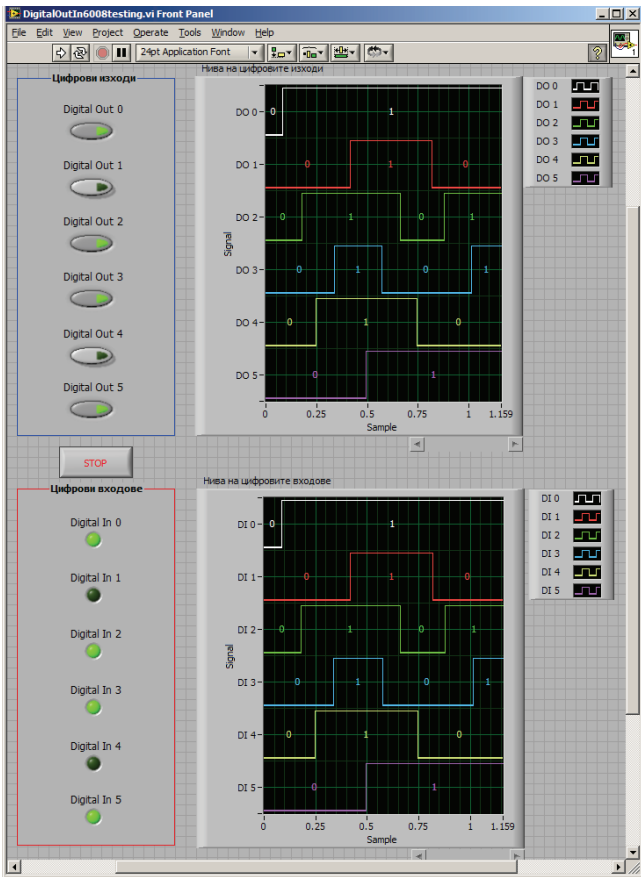


Fig. 7. Generation and acquisition of digital signals

IV. CONCLUSION

The results from the investigations show that the developed virtual system can be used for generating of low frequency analog signals and generating signals on digital outputs of the hardware module. It can be easily integrated in more complex software for automobile investigation which is based on the virtual instrument technology.

It is also possible to use the system for testing the efficiency of other virtual instruments developed for data acquisition of analog and digital signals.

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