A Virtual Instrument for Automobiles' Fuel Consumption Investigation

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Abstract: *A virtual instrument for investigation of automobiles' fuel consumption is presented in this paper. The purpose of this development is to automate and facilitate the research process in this field. As a development environment is used LabVIEW. The virtual instrument computes and visualizes the automobile's fuel consumption depending on the time of motion. This virtual instrument can easily be used as a module in more sophisticated systems for automobile investigations.*

Key words: *Virtual instruments, LabVIEW, automobiles*

INTRODUCTION

The tendency in the automobile industry is to pay more attention on the fuel consumption [6]. The determination of this characteristic is a part of the investigation programs of all automobile manufacturers during the process of test of the prototypes or new serial models [5]. It helps them to find the right ways to reduce the fuel consumption. Such tests are also made in service-stations. Some of these experiments include determination of the fuel consumption in dependence on the time of motion of the automobiles.

For the implementation of such investigations a microprocessor based system which collects data usually is used. In such case special software for calculations, visualizations and analysis must be used. The main part of existing specialized microprocessor systems includes only basic software which makes specific initializations and calculations.

One of the disadvantages of such systems is that they use specific software which is very difficult to program again. Another disadvantage is that their software is difficult to be integrated in more sophisticated systems for automobile investigations.

A solution of these problems is to develop and use a computer based virtual instrument for investigation the fuel consumption of automobiles. The advantage of such approach is that using virtual instruments, appropriate hardware and additional software [1] it is possible to create modular systems for measurements, experiments and autoimmunization of processes. If there is a change in the investigated system the virtual instrument can be easily expanded by adding additional functions. This gives an opportunity to create user defined solutions.

LAYOUT

The appropriate environments for development of virtual instruments are LabVIEW and LabWindows/CVI of the National Instruments Company, USA. Their main purpose is for development of virtual laboratories and to ensure distance experiments with these laboratories via Internet.

The programs which are created by LabVIEW are named virtual instruments because their appearances imitate the real devices [1]. The virtual instruments (VI) 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. The G program language has many functions for processing, working with various file formats, analysis, generation of signals and visualization of data.

The developed virtual instrument is a part of a system for automobiles' fuel consumption investigation. This system includes the following units (Fig.1): an object of the investigation (automobile); a primary transducer for fuel consumption (fuel flowmeter); a hardware module for measurement of signals and for data transfer to PC; a personal or Notebook computer containing software for data recording and virtual instrument which makes calculations, analysis of results and visualization of the fuel consumption.

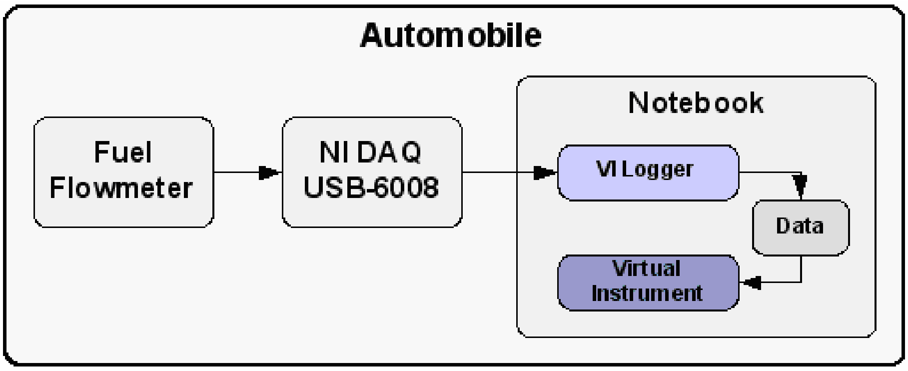

Fig. 1. A scheme of the system for automobiles' fuel consumption investigation

As a primary fuel transducer were used two different types of flowmeters – turbine (ARCO) and volumetric (RTG-1). The first flowmeter generates next to 16000 impulses per minute. This characteristic of the second flowmeter is different – it generates one impulse from 10 to 60 seconds depending on the fuel consumption.

The National Instruments DAQ USB-6008 device provides basic data acquisition functionality for applications such as simple data logging and portable measurements [3]. It is also powerful for sophisticated measurement applications. To begin taking basic measurements the NI USB-6008 can be used with the included ready-to-run data logger software (VI Logger) or with programs like LabVIEW.

For fast data preserving in real time the National Instrument software VI Logger was used. Its main advantages are that the user can tune each data channel and also that the program automatically records the received data in its own database. VI Logger provides necessary software tools to define and execute data logging tasks. With VI Logger the user can view real-time data in graphs, browse and manage historical data in graphs, and export data to visualize it in Web browsers and other applications [4]. The user also has a possibility to control data logging tasks in LabVIEW and to analyze recorded data.

Table 1

Turbine Fuel Flowmeter			**Flowmeter RTG-1**		
NI VI Logger Created: 26.1.2006 15:05:21.940 Number of scans: 32207 Scan rate: 0.001 seconds			**NI VI Logger Created: 25.1.2006 11:41:29.839 Number of scans: 1300 Scan rate: 0.01 seconds**		
Row	**Time**	**Voltage**	**Row**	**Time**	**Voltage**
1	15:04:47.234	-1.35516	1	11:41:14.765	10.3920
2	15:04:47.235	-1.35516	2	11:41:14.775	10.3818
3	15:04:47.236	-1.35516	3	11:41:14.785	10.3818
4	15:04:47.237	-1.35516	4	11:41:14.795	2.4792
5	15:04:47.238	-1.35516	5	11:41:14.805	10.3717
6	15:04:47.239	2.91654	6	11:41:14.815	10.3717
7	15:04:47.240	2.90637	7	11:41:14.825	10.3818
8	15:04:47.241	2.91654	8	11:41:14.835	10.3717
9	15:04:47.242	2.91654	9	11:41:14.845	10.3818
….	….	….	….	….	….

By default NI Logger automatically adds to each data file a header with information (date, hour, number of scans, scan rate) of the carried out experiment. In Table 1 are shown the results of conducted experiments with the two types of fuel flowmeter. From these results can be seen that these flowmeters generate signals with different characteristics. The signals from the turbine fuel flowmeter are in the range between -1.35 V and +2.92 V, while the signals from the flowmeter RTG-1 are positive between 2.40 V and 10.40 V. This enforces that the virtual instrument must make an analysis of the signal's values and has to perform an additional processing in order to present the signals as impulses in a graphical form.

On Fig.2 is presented the Front Panel of the developed virtual instrument. This panel includes several object types for input and output of an information: a field where the user types the fuel's amount corresponding to one impulse of the flowmeter; a slider with which the user gives the number of sequential impulses for calculation of the fuel consumption; text fields for file's information; text fields for output of the calculated information; two objects for a graphical presentation of the flowmeter experiment data and for the calculated fuel consumption in dependence on the time.

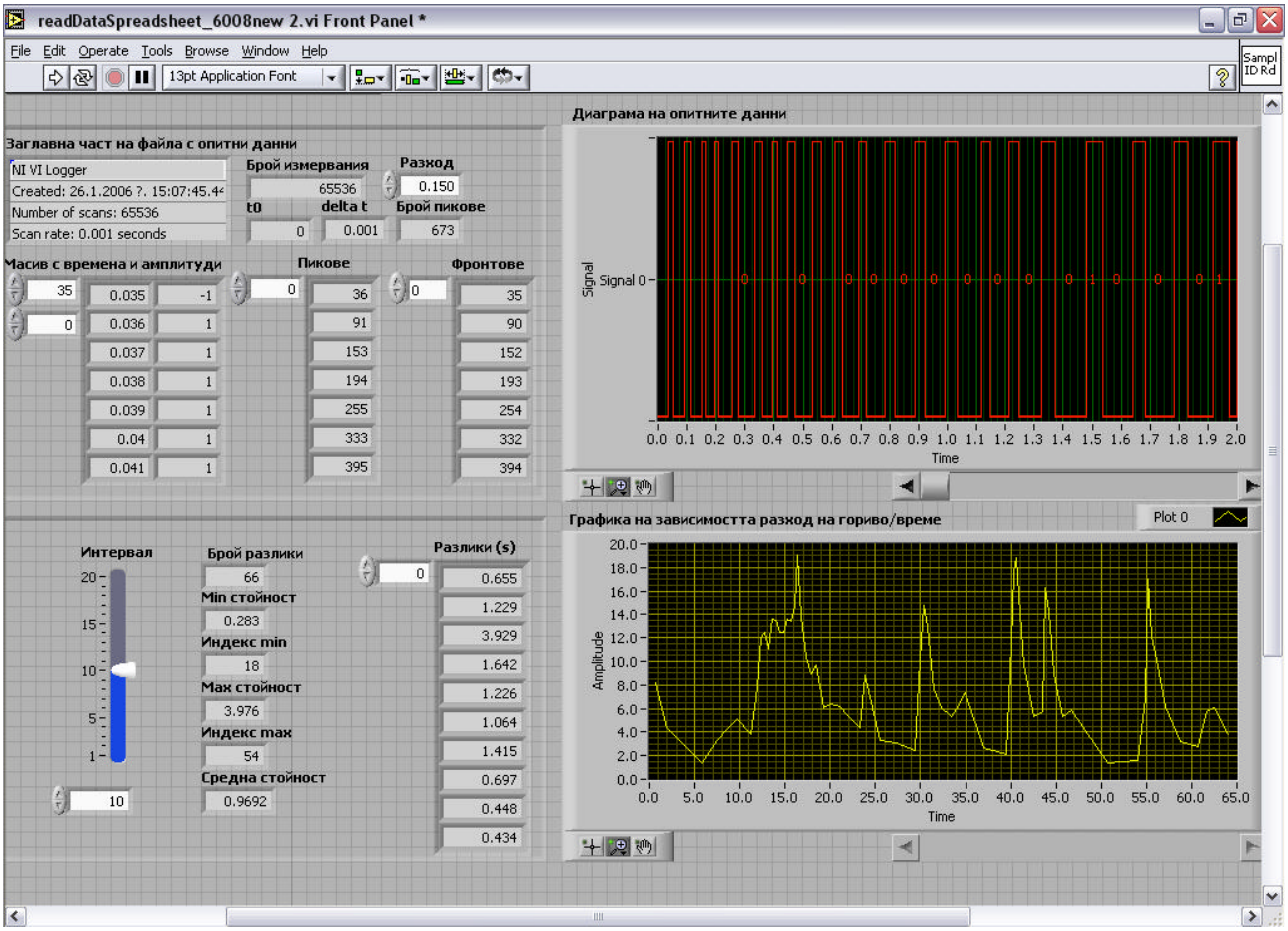

Fig. 2. The Front Panel of the virtual instrument

The working algorithm of the developed virtual instrument is the following:

1) The user inputs the value of the constant Δg which shows the portion of fuel corresponding to the one impulse of the flowmeter. The default value is 0.15 cm^3/impulse.

2) The user can give the number of sequential impulses k for calculation of the consumption. If the k>1 this means that a duration of k numbers of impulses is summarized. For these k impulses the portions of the fuel are also calculated by multiplying the constant Δg by k. The default value for k is 1 which means a calculation of the fuel consumption for each impulse.

3) The user selects the data file to be processed and visualized on the Front Panel.

4) The data from the selected file are read by the virtual instrument.

5) The information from the file's header has to be extracted and displayed in the text field on the Front Panel.

6) The information about the number of scans, initial time value and scan rate has to be extracted from the header and displayed in the corresponding fields.

7) The values of the signal have to be normalized and the number of impulses generated by the fuel flowmeter has to be estimated.

8) The analog signal has to be converted to digital signal. On Fig.2 an example of digital signal is presented (the graphic in the top right corner).

9) Determination of the duration of each impulse of the signal. This step is very important, because the duration changes in opposite proportionality to the fuel consumption. When the rate of consumption is high then the duration of the impulses is short, when the rate of consumption is low the duration is long.

10) The information about the duration of each impulse have to be displayed on the Front Panel.

11) Calculation and presentation of the minimal, maximal and average value of the duration of the impulses.

12) The next step is a calculation of the fuel consumption in dependence on the time. On Fig.3 is presented a part of the Block Diagram which makes this calculation. During the development of the virtual instrument the LabVIEW program environment and its program language G were used. The main program structures and functions which were utilized are: For cycle, Case structure, function for string and array manipulation, algebra and logical functions, functions for processing of analog and digital signals, etc.

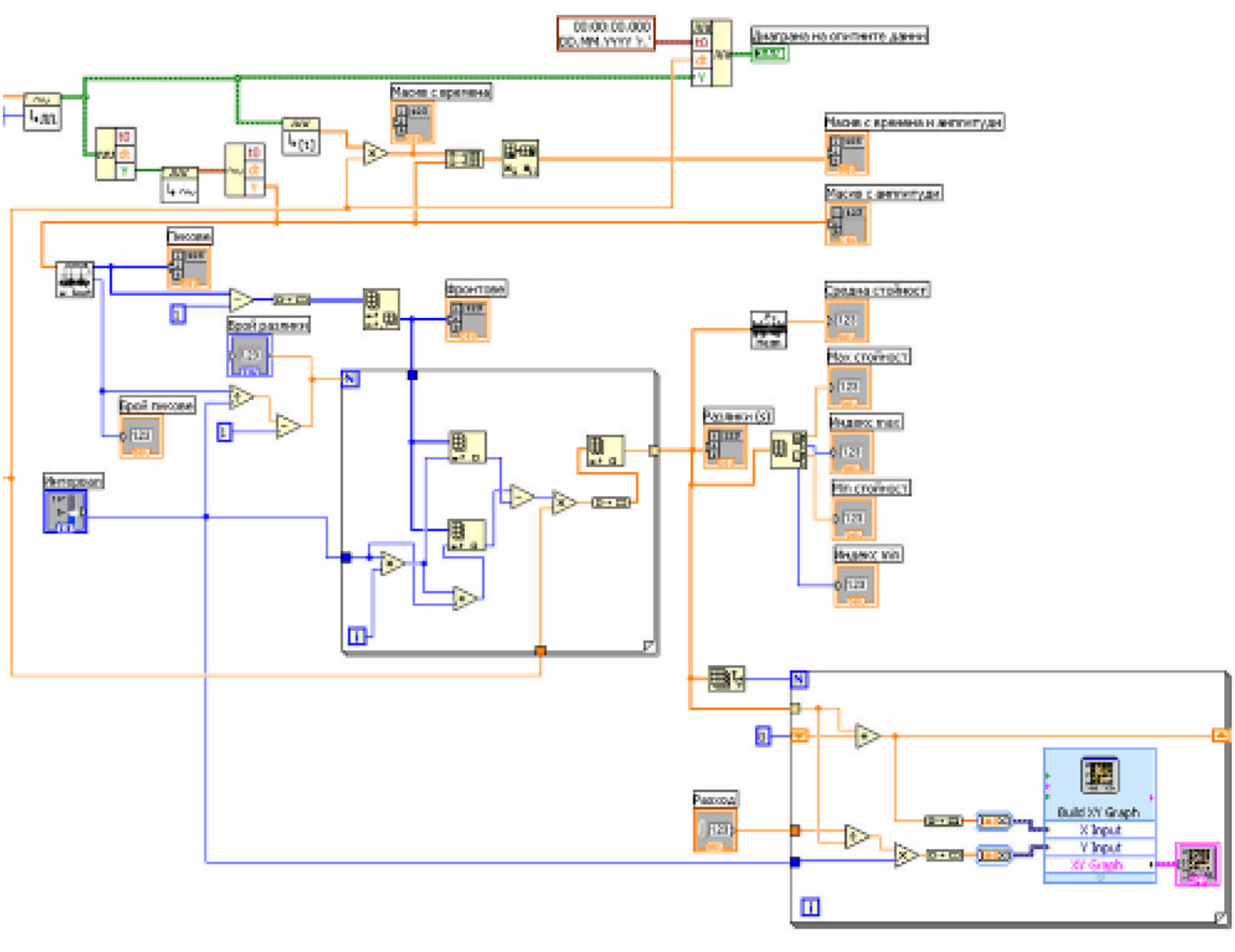

Fig. 3. A part of the Block Diagram of the virtual instrument

If the user inputs a number of sequential impulses for calculation of the consumption equal to one, then the following formula is used:

$$G_{h_i} = \frac{\Delta g}{\Delta t_i}.3{,}6\text{ , l/h ,} \quad \text{for i=1,...,n} \qquad (1)$$

where:

Δg is the portion of the fuel for one impulse of the flowmeter, cm^3/impulse;

Δt_i - duration of the i-impulse, sec;

n - the total number of recorded impulses.

When the number of sequential impulses for calculation of the consumption is k>1, then formula (1) transforms to:

$$G_{h_j} = \frac{k.\Delta g}{\sum_{i=1}^{k} \Delta t_{(j-1)*k+i}}.3{,}6\text{ , l/h,} \quad \text{for j=1,…,m} \qquad (2)$$

where:

G_{h_j} is the fuel consumption for k numbers of sequential impulses of the flowmeter;

m - the integer part of the division of the total number of the recorded impulses n by the number of sequential impulses for calculation of the consumption k: m = n div k.

13) The dependence G_h=f(t) have to be presented in a graphical form. On Fig.2 this is the graphic in the bottom right corner.

CONCLUSIONS AND FUTURE WORK

The results from the investigations show that the developed virtual instrument can be used for calculations, visualizations and analysis of the economic characteristics of the automobiles. It can be easily integrated in more complex software for automobile investigation which uses the virtual instrument technology.

One of the future tasks will be integration in the virtual instrument an ability to calculate the value of each fuel portion depending on the time duration of the impulses generated by the flowmeter. Other task is connected to the development of virtual instrument which will calculate and visualize not only the fuel consumption depending on the motion time but also the fuel consumption depending on traveled road, as well as depending on the velocity of the investigated automobile.

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