Časopis priemyselnej elektrotechniky (JIEE)
Journal of Industrial Electrical Engineering
ISSN 2454-0900
www.jiee.eu

Simple digital voltmeter and signal generator realized by PC

[1]*Irena KOVÁČOVÁ*

[1] Department of Theoretical and Industrial Electrical Engineering, Faculty of Electrical Engineering and Informatics, Technical University of Košice, Slovak Republic

[1]irena.kovacova@tuke.sk

***Abstract* — The paper describes the two designs of automated measurement systems for measuring of the analog and digital input signals and generating of the reference output signals.**

***Keywords* — automated systems, measuring, signal generating**

I. Introduction

The development of digital elements allows apply digital techniques also for measuring and evaluating of various quantities. The main element of the digital automated measuring system is a digital control element, which can be represented by a digital signal processor or a personal computer. The purpose of these systems is to reduce amount of a man work during measuring and data processing. In some causes is a measuring without automated measuring systems impossible, for example in complex systems, where measured data are used for regulation of other subsytems. Automated measuring systems are able to increase the precision of measured data by statistical methods utilizing.

II. Hardware connection

We have two main ways for interconnecting of external devices and standard PC. The first is the direct connection to the one of the computer buses via slots and user cards inserted to the motherboard. The second way of interconnection can be done via standard PC ports.

III. User card connection

An example of simple hardware connection of automated measuring system is shown in Fig.1. The whole connection is designed as measuring board for the IBM PC slot. It consists of the three input-output channels: one digital and one analog input channels and one digital output channel. The separating of digital input signals (K1) from the IBM PC data bus is secured by the two three state bi-directional separators (IO1, IO2). The first separator separates the IBM PC data bus from the internal board data bus. Interconnection of the mentioned data busses is allowed only in the case of coincidence of a two binary address bytes. The first address byte is the address word transmitted by the IBM PC on the address bus. The second address byte is given by combinations of the states of the DIL switches, which gives chance to choose the base address of the measuring board. The standard address for the user board is 300H. The both address bytes are compared in the address comparator IO3. The output of IO3 will generate the output signal with level log. „0“ in the time of the equality of mentioned address bytes. This fact causes the opening of the separator IO1 and the data flow from the PC to the board. The gate signal on the IO1 has value log. „1“. If the gate signal on the IO1 is log. „0“, so the data flows from the measuring board to the PC data bus. The access of the input and output signals from the individual three channels to the internal data bus is secured by activating of the

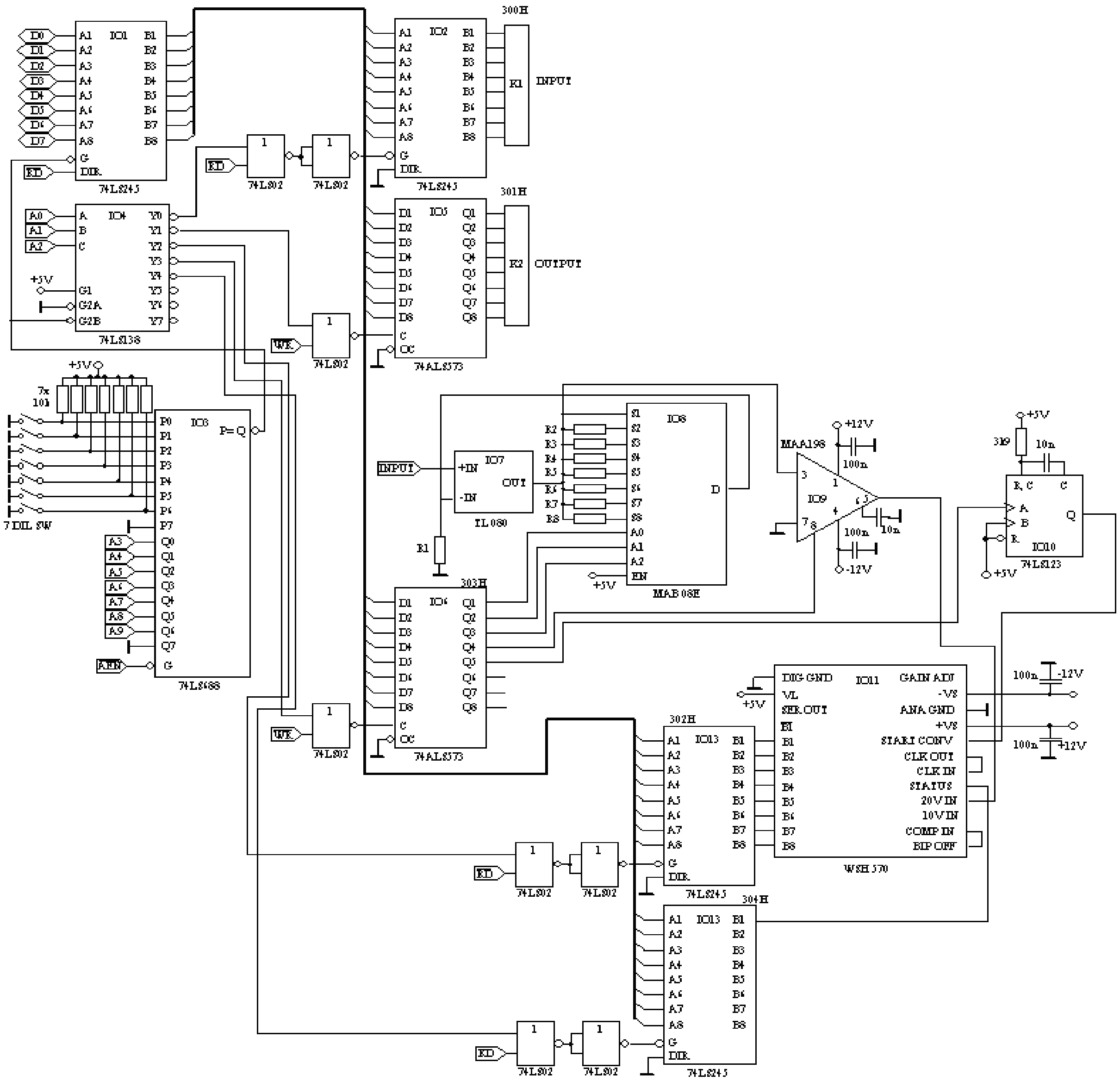

Fig. 1 Hardware connection of designed automated measuring system

individual channel separators. The first three address bits which send the PC to the address bus, and which are connected make this activation to the address decoder 1 from 8 IO4. Then we can open the common separator IO1 and one of the outputs or inputs channel separators by the right addressing. Also it is useful for right timing, if the signal from the address decoder IO4 is logically connected with the reading signal $\overline{\mathrm{RD}}$ or writing signal $\overline{\mathrm{WR}}$, which are transmitted from the PC. So we can read the data from the digital input K1 by transmitting of the address byte 300H from the PC. Similarly, we can transmit the data from the PC to the digital output K2, if we will transmit the address byte 301H from the PC. The valid data are passing thought the PC data bus in the both cases. One can see, that the solving for the obtaining of the digital input or output is very easy. The requirement of the measuring of analog input signals brings a little bigger problem. The analog input signal must be in advance transformed by the IO7 and IO8. These circuits are functioning as the programmable operational amplifier. Then the input amplification will be given by values of the resistors R1 to R8 and the equation (1) as:

$$A_{U_{21}} = \left(1 + \frac{R_2}{R_1}\right) \qquad (1)$$

ISSN 2454-0900

The choice of the resistor R2 is made by the eight channels analog multiplexer IO8. The value of the resistor, which is connected between the input and output terminals of the IO7 is so determined by the three bits A0 to A2 on the address input of the IO8. These bits we can choose by the data, which we are sending by the PC data bus to the busses separator with the address 302H. The same procedure will to secure the timing for sampling and starting of conversion of the A/D converter. For analog to digital signal conversion is used 8 bits A/D converter of the type WSH570-IO11, which allows the parallel and serial interconnection of the digital output signals. In our case is used only the parallel digital output signals, which are connected to the internal data bus by the busses separator IO13 with its address 302H. The conversion time of the A/D converter is typically 6μs and its input is adjusted to the range ±10 V. Because the input signal must have the constant value during conversion, so is necessary to use the sampling operational amplifier IO9. For the starting of conversion of the A/D converter we must to transmit the starting impulse to the A/D converter by the PC data bus, by the busses separator IO12 with address 303H and by the monostable flip-flop circuit IO10. The value log. „0“ across the terminals with the designation „STATUS“ gives the finish moment of the conversion. So we must to check the mentioned signal and we will make it with the same procedure as the reading of the digital input data, but with the different address of the data busses separator, which is in this case 304H.

IV. Programming and program tools

One can make the writing of the control program in any higher programming language as for example the Turbo Pascal, the C language, the Basic and many others or in the Assembler. For example, the typical Turbo Pascal instruction for getting the data from the output to the variable X is:

$$\text{X:=Port[\$300];} \qquad (2)$$

and for transmitting data from the PC to the output is:

$$\text{Port[\$301]:= \#data;} \qquad (3)$$

It is evident, that the obtaining or sending of the data is very easy. So we can get any number of the input samples and then we can use the statistical methods for its evaluation. Such type program results are shown in Fig. 2. The user can to choice the number of the samples, which are then measured and saved to the file with the name, which is given by the user. The program then calculates the average value, the dispersion and show in PC's display the value of the each samples related to the average value.

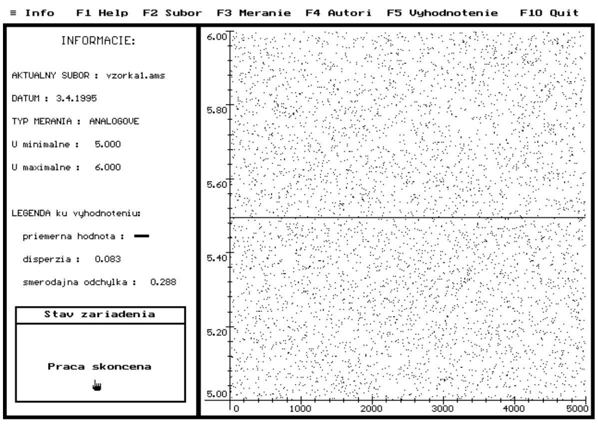

Fig. 2 Program for evaluating of measuring

The digital output of the designed measuring board can be used for the digital control of the two state electrical parts, too. The example of the two state solenoid valves control is shown in Fig.3. The operator can see its states in the technological structural scheme of the production and can to switch its states from the PC.

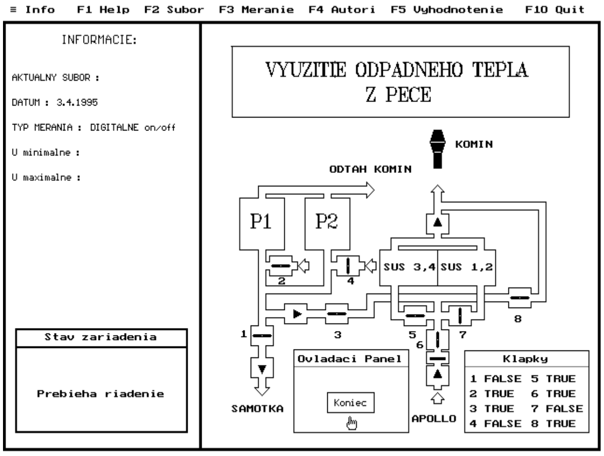

Fig. 3 Program for digital control

The abilities and properties of the all such programs are strongly dependence on the abilities of the programmers.

V. Standard PC port connection

If we want to use standard input-output ports we can choose serial (COM), parallel (LPT), USB port or game port. The option of interface depends primary on the required data transfer speed and required number of inputs/outputs. For lower speed and lower number of inputs/outputs one of the standard ports is sufficient, however if we require higher speed and/or number of inputs/outputs, then we must choose one of the modern buses.

In due to simple operation the connection via parallel port has been chosen for described design. Such decision has been done also for sufficient number of required inputs/outputs. For the digital voltmeter is the speed of the parallel port sufficient. However the signal generator depends on overall performance of a computer, which is one of the limiting factors here.

VI. Digital voltmeter hardware design

Figure Fig. 4 shows the basic block diagram of the digital voltmeter.

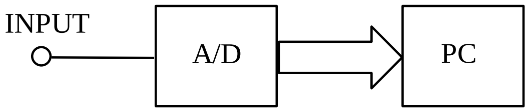

Fig. 4 Block diagram of digital voltmeter

In due to that a parallel port has purely digital inputs and outputs it is necessary to convert an analog input signal to a digital one. This is done via A/D converter. Output converter values are read via the parallel port and are further processed and shown by the PC. Fig. 5 shows the hardware solution of the digital voltmeter.

As A/D converter a C520D chip is used. This chip is used for representing voltage values from 0 to 999mV on three 7-segment display units. By using the ladder it is possible to connect a maximum voltage of 99.9V to the voltmeter input. A representation of a value is done at the principle of sequential switching between individual display units while showing a proper number for this unit.

ISSN 2454-0900

The outputs N, M, L determine, which unit is currently active (at the correspondent output is log.0, at the others is log.1) and at the outputs OA, OB, OC and OD is a number in a BCD code to be shown on an active unit. States of all this outputs are read via the parallel port and processed by the program, which evaluates incoming data and shows them as a three-digit numeric reading.

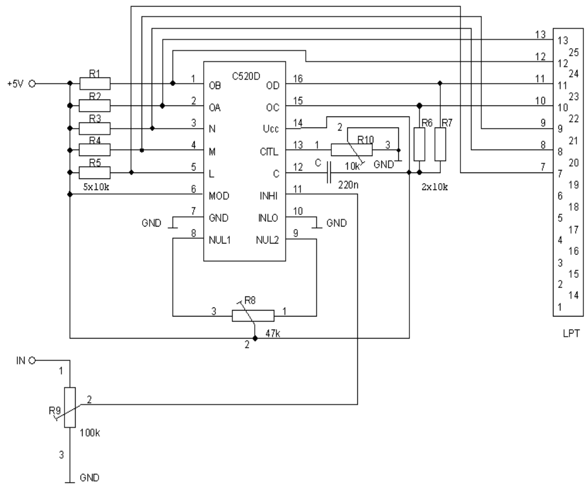

Fig. 5 Digital voltmeter design

VII. GENERATOR HARDWARE DESIGN

Figure Fig. 6 shows the basic block diagram of the signal generator. The detailed connection is shown in Figure Fig. 7.

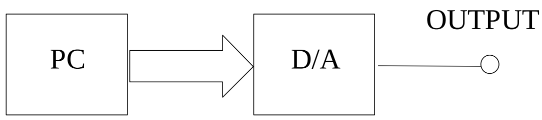

Fig. 6 Block diagram of signal generator

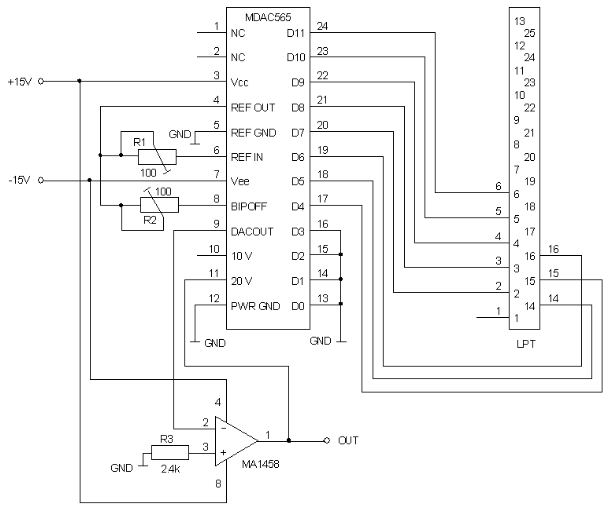

Fig. 7. Signal generator design

The generator circuit uses 12bit D/A converter MDAC565. Due to restriction on number of port outputs only 8 higher bits are used. By driving an 8-bit number at the inputs of D/A converter a proportional current will occur at its output. The converter has a current output and therefore the

ISSN 2454-0900

computing amplifier MA1458 is attached to this output, which converts this current to a voltage. By the set shape of a signal program generates a sequence of binary numbers send via the parallel port to the inputs of the D/A converter, which converts this numbers to a shaped current.

VIII. Software design solution

The Fig. 8 shows the main window of the program Voltmeter used for displaying and storing measured voltage. The largest part of the window takes digital indicator showing currently measured voltage. Below is the history graph showing measured voltage in a certain time interval. This interval is dependent at the set speed of voltage value readings. This speed can be set from 0.1s to 45 days. Read values can be saved to a file in TXT or XML format for further process, too (statistic, graph, etc.). To start the measuring process press the Štart button and to stop it, press the Stop button. The Fig. 9 shows the main window of the program "Generator signalov" used for setting the output signal. It is possible to set a frequency (Frekvencia), voltage peak-to-peak value (Uss), voltage offset (Offset), signal polarity (Polarita signálu) and signal shape. The quality of the output signal depends in a high degree on overall performance of the computer and its actual load. Unipolar signals can have voltages from 0V - +9.9V and the voltage of bipolar signals can be from -9.9V - +9.9V. Minimal frequency of the signal can be 0.1Hz, maximal frequency is not restricted, but 1000Hz is recommended. Signal generation can be started press the Štart button and stopped press the Stop button.

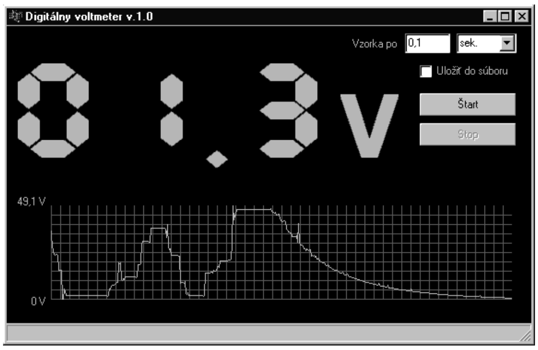

Fig. 8. Digital voltmeter program screen

Fig. 9. Signal generator program

IX. Conclusion

From the above mentioned facts is evident, that the hardware and software tools of the described automated measuring system are very simple. This is therefore, that it has been made as a result of the students teaching activity at the Department of Theoretical and Industrial Electrical Engineering, TU Košice. All programs were designed for use with Win9x operating systems.

Digital voltmeter could include for example overvoltage protection at its input and a channel switcher for measuring multiple voltages "simultaneously". Some extensions of the signal generator could include for example a filter for output a signal quality improvement, program extensions could include more signal shapes and the possibility to use these programs with Windows NT and Windows XP operating systems.

REFERENCES

[1] Kováčová, I., Kováč, D.: Modelling and Measuring of Electronic Circuits, textbook FEI TU Košice, *ELFA s.r.o. Publisher*, 1996, 92 pages, ISBN 80-88786-44-4

[2] Kováč, D., Kováčová, I.: Microcomputer Controlled Drive with MOSFETs for High Speed DC Motors, *Proceeding of 7-th International Conference on Electrical Machines and Drives*, Varna, 1993, pp.7-13

[3] Gallová, Š.: Reasoning Using Entropy Inference in Machinery System Diagnostic Procced. medz.kongres MATAR Praha 2004, sept.2004, s.131 - 135

[4] Kováčová, I., Kováč, D., Oetter, J.: Applied Electronics, textbook, Košice, *Akris Publisher*, 2001, 94 pages, ISBN 80-968666-0-5