

VIRTUAL INSTRUMENTS IN THE PROGRAM OF THE ELECTRICAL MEASUREMENTS CHAIR (TUG)

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Abstract: The paper presents the experience of the team of the Technical University of Gdansk (TUG), Chair of the Electrical Measurements in using Virtual Instruments for educational purposes. These instruments can be used with great success for demonstration different physical phenomena during the lectures, especially to present different rapid effects in slow down time scale. They form marvellous help in understanding many theoretical problems. The virtual instruments can also be used in the virtual home laboratory, which enables students better preparation for real laboratory tasks. It is also possible to design specialised instruments for practical works in students laboratories and to substitute stand alone instruments which are sometimes inaccessible due to anxious financial situation of our faculty.

Keywords: Education in Measurement, Virtual Instruments, Virtual Laboratory

1 INTRODUCTION

The development of present-day technique is strictly connected with the computer technology. It enters not only into many fields of science but also into educational process in which figure prominently virtual instruments (VIs) [1-4]. In educational process the VIs can be divided into three groups:

1. Virtual instruments co-operating with real instruments and transducers compose a part of measuring or controlling system.
2. Virtual instruments acquiring the computer's network enable to watch the same process using many computers. They enable the remote control of different processes and to watch the process, which can not be realised in the educational laboratory due to high costs of instruments. It is also possible to watch the processes realised in dangerous or inaccessible places e.g. in the cosmos.
3. Virtual instruments simulating genuine phenomena (Demonstration Virtual Instruments - DVIs) or real measuring tasks (Training Virtual Instruments – TVIs). They are used during the lectures and enable better comprehension of theoretical problems, as it is possible to demonstrate rapid phenomena in slow down time scale in the educational process. Using them as training simulator students have the possibilities fore better preparation to measuring tasks in the universities' laboratory.

Everyone knows that good technical lectures of electrical measurements have to be assisted with special demonstrations, which are more worth then many words. In order to prepare these demonstrations it is necessary to have access to special lecture-rooms so called "lecture theatres". This situation is critical in the Electrical and Control Engineering Faculty of the Technical University of Gdansk (TUG). In order to overcome these difficulties the team from the Chair of Electrical Measurements (TUG) has designed numerous DVIs. They are used during the lectures and their main advantage is that the theory verified immediately with practical examples is easier to be well understood and retained. These demonstrations are accessible for students by Internet or with the help of CD-ROM. They are also very convenient as an educational tool during the examination period.

The laboratory of electrical measurements is for many students the first contact with the electrical instrumentations. For this reason they have great problems in practical realization the defined measuring tasks. Moreover the precise electrical instruments can be spoiled accidentally by students' ignorance or stupidity. To eliminate these hazards the team from TUG have designed many virtual training stands. They are realized in the form of defined measuring circuits in which created VIs are analogous to the instruments applied in the university laboratory. This virtual laboratory is realized in the form of CD-ROM and is known as "Virtual Home Laboratory of Electrical Measurements" (VHLEM). With the help of this tool everyone has possibility to perform the virtual measuring task at home and may be accustomed with the manipulation of the real measuring instruments which are used in the university laboratory. Furthermore during the training the student is immediately informed about wrong manipulation, which may damage the controlled instrument.

2 GENERAL INFORMATION

The first step which must be fulfilled before designing VI for educational purposes is the choice of the right software. From the point of view of the team of the Chair of Electrical Measurements very convenient is LabVIEW software of National Instruments. It has been already used by the Chair's staff for last six year in the research laboratory. Its main advantages are:

- it has very comprehensive library with many examples and for this reason the productivity of designing adequate instruments is 5 to 10 times better in comparison with the software based on conventional language (very important fact as the number instruments which must be designed is great),
- its built in graphical user interface is intuitive in operation, simple to apply and as a bonus, nice to look at,
- transforming designed VIs with help of Application Builder of National Instruments it is possible to used them with PC equipped only in Windows environment (very important for students training with virtual home laboratory for the real tasks in the university laboratories as most of them have not possibility to profit by LabVIEW software at their home computer).

The practical solutions of the virtual instruments presented in the paper in the form of DVIs and VHLEM enable to understand better the idea of their creation and conveniences of their use in the educational process.

3 PRACTICAL SOLUTION

3.1 Demonstration Virtual Instruments – DVIs

Nice and clear figures and diagrams presented during the lectures by means of overhead projector or beamer are usually more worth than thousand words. However many problems could be better explained by means of virtual instruments or virtual systems with animation. Using them it is possible to explain:

- different static features of analogue and digital instruments, their behavior in dynamic state and it can be performed in slow down time scale,
- effects of different disturbances on the operation of analogue and digital instruments, especially influences of temperature errors, supply voltage distortion and influences of electromagnetic fields.

A simple example of DVI in the form of vibrating reed frequency meter is presented in Fig. 1a. This instrument enables to set an arbitrary value of frequency using vertical pointer slide of frequency generator and to read instrument's indication.

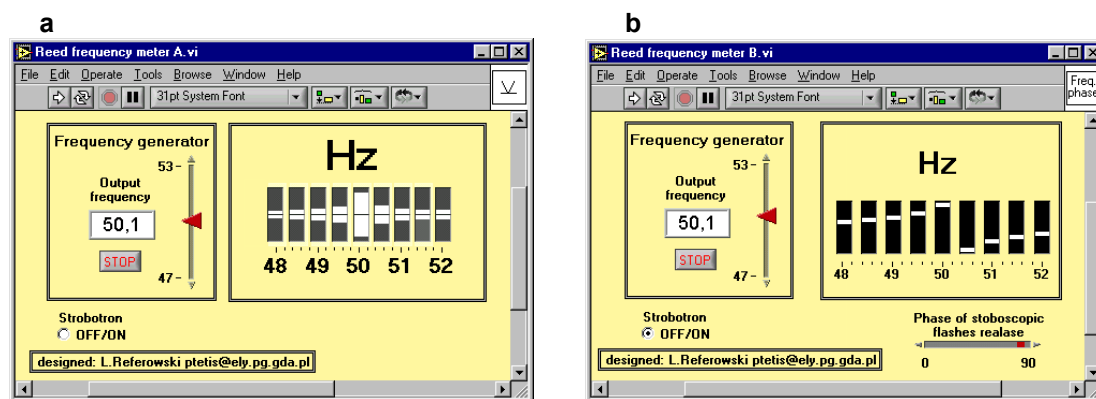


Fig. 1. Demonstrational vibrating reed frequency meter:

a) frequency measurement, b) demonstration of phase response of second order transducer

The reed frequency meter can also be used for demonstration the phase response of the second order transducer in the case of very low value of damping coefficient in the proximity of resonant frequency. The output signal in this case abruptly changes phase shift about nearly 180°. To show this effect the indicator of frequency meter is illuminated by a stroboscopic tube controlled by measured frequency. When the moment of flashes is good adjusted the reeds with natural frequency below the value of measured frequency (equals to the frequency of flickers) are in opposite position to the reeds with natural frequency above this value (Fig. 1b).

The frequency of generator presented in Fig. 1 can also be measured by means of digital frequency meter presented in Fig. 2.

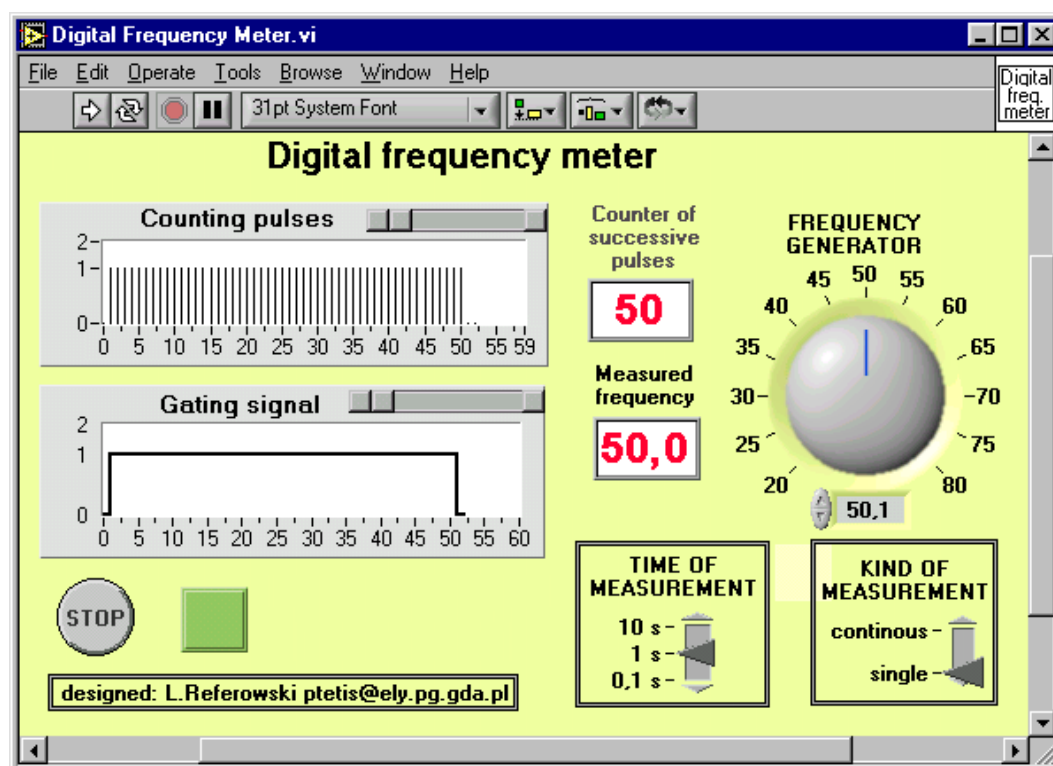


Fig. 2. Digital frequency meter

Another example of DVI is a digital voltmeter with dual slope integration presented in Fig. 3. This instrument enables to explain during the lecture the principle of its work during the first and the second step of integration and pulses counting in the case of:

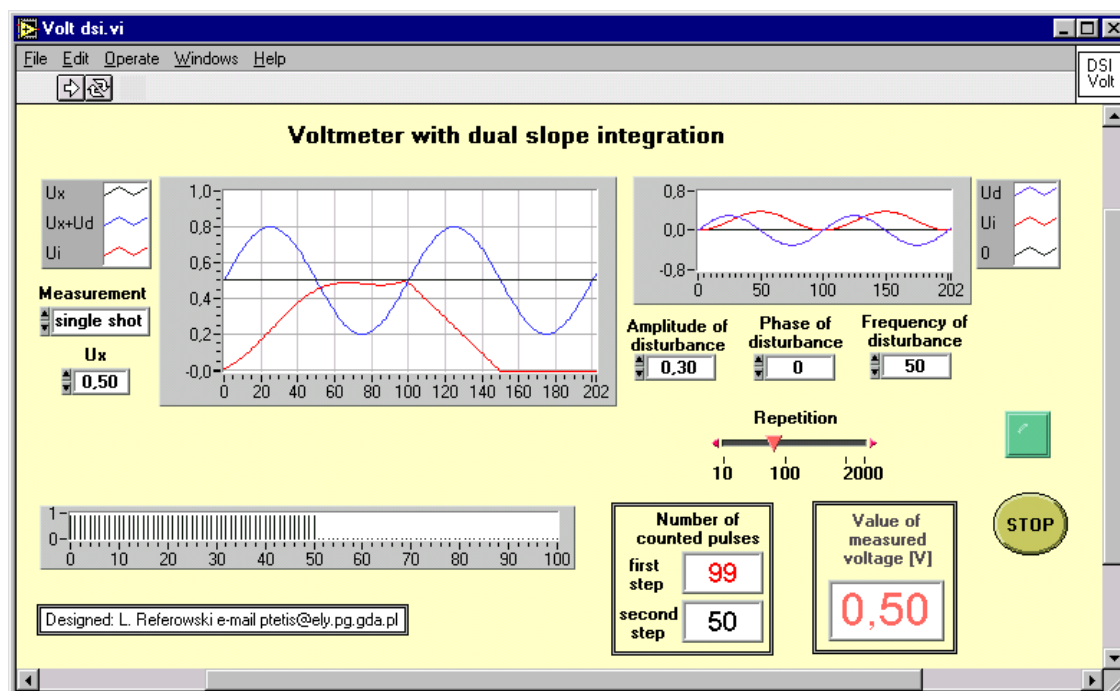


Fig.3. Virtual digital voltmeter with double slope integration, time of first step integration equal to period of disturbance frequency

- normal condition of work – AC disturbances do not exist,
- presence of disturbances with frequency of 50 Hz – no effects on the results of measurements (Fig 3),
- presence of disturbances with frequency which is different from 50 Hz – significant occurrence of measuring error (Fig 4).

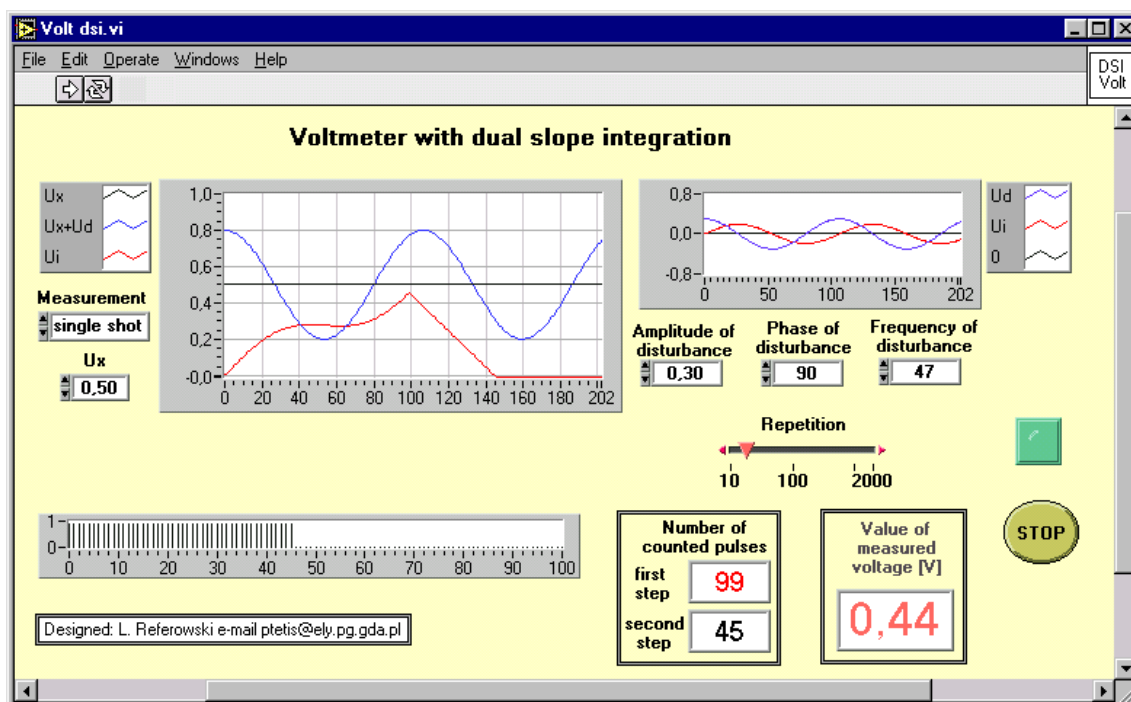


Fig. 4. Virtual digital voltmeter with double slope integration, are different

When the time of integration t of the measured voltage $u_x = 0,5V$ is equal to the period T_d of disturbance voltage $u_d = 0,3V_{max}$ (eg $t = 20ms$) the value of output signal u_i from integrator at the end of the first step of integration is equal to the value of measured voltage, so there is no influence of disturbance signal on the result of measurement (Fig. 3). The same effect of elimination disturbances is observed when the frequency of disturbance is k time greater, (k is integer). On the other hand when the time of integration of the measured voltage is different from the period of disturbance voltage ($t \neq T_d$) the value of output signal u_i from integrator at the end of the first step of integration differs from the value of measured voltage ($u_i \neq u_x$) and the error of measurement occurs (Fig. 4, the value of measured voltage is 0,44V instead of 0,5V).

3.2 Virtual Home Laboratory of Electrical Measurements - VHLEM

Virtual instruments are also very helpful as aid materials which enable the better preparation for laboratory tasks. Usually students obtain the aid materials from laboratory's staff in form of printed instruction. But the possibility of performing virtual measurements in moment of reading them is a very helpful solution, especially for the students who have the first contact with measuring technique [5]. It is necessary to underline that the virtual laboratory in educational process can not replace the real university laboratory, it can be only treated as a help for better preparation for real laboratory jobs.

As an example in the Fig 5 is presented a stand for strain measurements by means of strain gauges. It is possible to adjust the dimension of the tested beam, its Young's modulus and Poisson constant. The strains can be measured in different bridge connection:

- quarter bridge with one active gauge,
- half bridge with one active and one dummy gauge taking into account the value of Poisson constant on the sensitivity of measuring circuit,
- full bridge with two active and two dummy gauges, the sensitivity of measuring circuit is 2 times greater in comparison with previous one,
- full bridge with four active gauges, the sensitivity of measuring circuit is 4 times greater than in the case of quarter bridge.

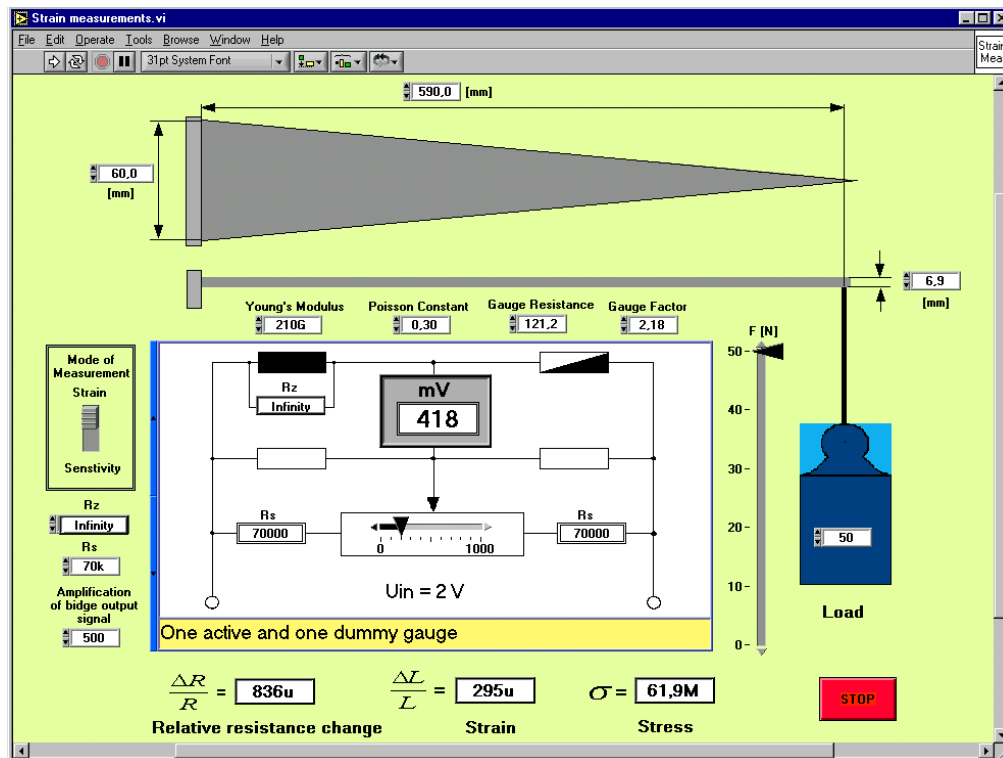


Fig. 5. Stand for strain measurements

At the beginning of measuring session it is necessary to balance the bridge with the help of trimming potentiometer. Then it is possible to measure the sensitivity of the bridge switching on the shunt resistor R_z and reading the value of the output voltage. Afterwards are performed the strain measurements for different values of load. It is possible to compare the sensitivity of different bridge connections and to match the amplification of output voltage in such manner that the values of milivoltmeter's indication corresponds strictly to the value of measured strain.

The second example of VHLEM is the stand for measuring temperature of liquid in tank with electrical heater (Fig. 6). As the electrical sensors are used the platinum resistance thermometer Pt100/138,5 and the iron-constantan thermocouple J.

The resistance of Pt100 sensor is measured with the help of Wheatstone bridge in which it is necessary to choose the right values of ratio resistance. The balance of the bridge is obtained by adjusting the right value of 5-decade resistor. Pressing the key switch activates the galvanometer. The switch *Sensitivity* changes the galvanometer's sensitivity from *Low* to *High* value. The balance of the bridge is obtained by adjustment the value of 5-decade resistor. The measured resistance of Pt thermometer is equal to the adjusted value of the resistance multiplies by the factor 0,1 (quotient of the ratio resistances).

The EMF of the thermocouple is measured by means of technical potentiometer. Potentiometer is fed from internal dry cell. For adjusting the proper value of feeding current internal standard Weston cell is used (mode switch in position E_n). The feeding current is controlled using knobs *coarse* and *fine*. Pressing the key activates the galvanometer. Its sensitivity can be changed selecting position *Low* and *High* value. The measurement of the EMF of thermocouple is realised with mode switch in position *Ex*. The adjusted values of decade resistor in the balance state of the potentiometer determines the value of measured EMF in millivolts.

Another example of the stand designed for VHLEM is presented in Fig 7 and is used for remote measurement and control of the level in the open water tank. In this case information concerning water level from publisher (Fig. 7 a) are transfer to subscriber (Fig. 7 b) by Internet using Data Socket Technology [6].

The actual value of level is detected with help of multiturn absolute encoder type CP-850-24MT. It has resolution of 24 bit per turn and has possibility of counting the number of turn up to 24-bit. The absolute encoder is coupled with the driving wheel. Its perimeter is equals 50 cm. This wheel is driven by a whipping line equipped with a float on the one end and with a balance weight on the other end.

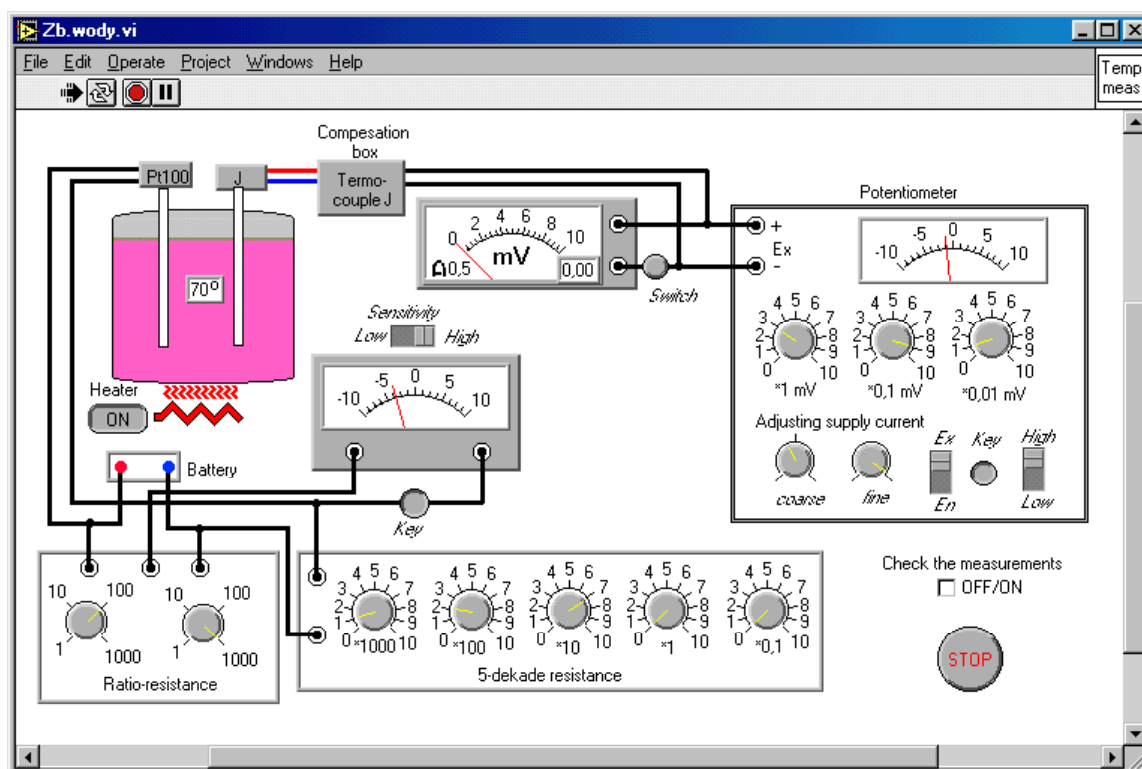


Fig. 6 Temperature measurements by means of platinum resistance thermometer (Pt 100/138,5) and iron–constantan thermocouple (thermocouple J)

The transducer's signals by means of interface RS-232 are transmitted to the computer, which is situated near the tested reservoir, connected to the Internet and equipped with the DataSocket server (Fig 8). The server registered the information concerning variation of the liquid's level. An optional user

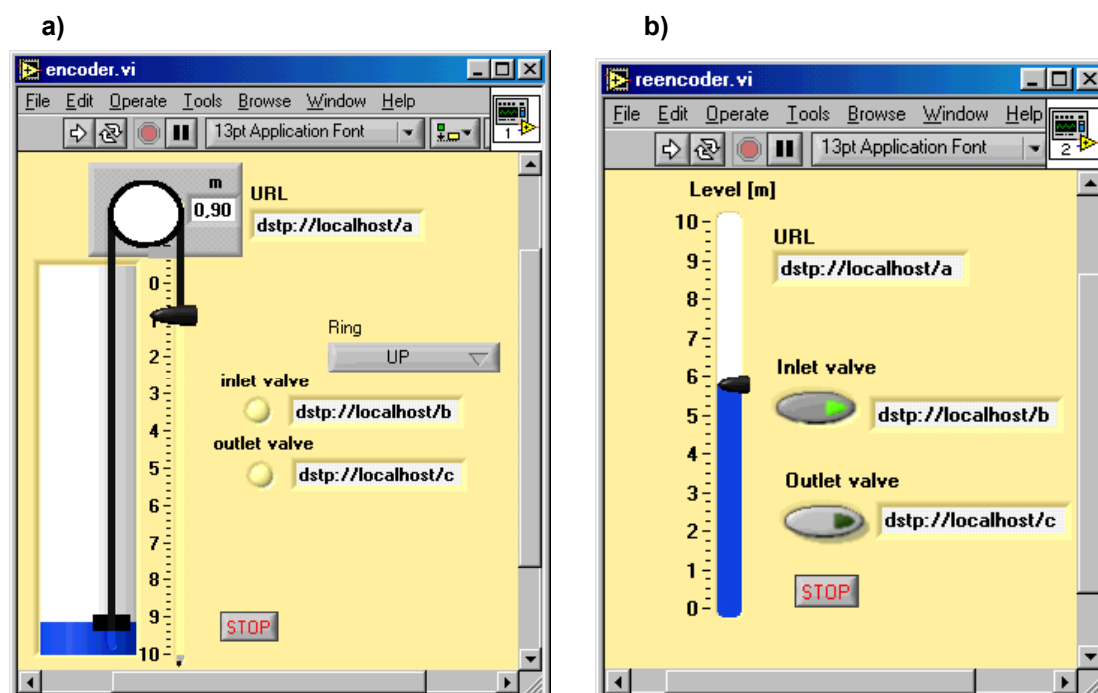


Fig. 7. Stand for remote measurements and control water's level in the open tank
a) DataSocket Publisher, b) DataSocket Subscriber

of the Internet can obtain information concerning actual value of the liquid's level and its background from the DataSocket server.

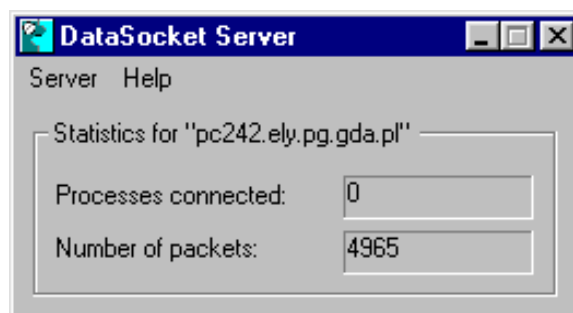


Fig. 8. DataSocket Server

The only condition necessary to obtain the data concerning the water level in the tank is to know the right URL (Uniform Resource Locator) address. The values can be read using Subscriber LabVIEW application (Fig. 7 b). From the Panel Window of this VI it is possible for user with password to control the liquid's level in the tank pressing control buttons of *Inlet valve* and *Outlet valve*. The state of the controllers are overwrite to the DataSocket server and the computer situated nearby the water reservoir stand, equipped with the Publisher/Subscriber LabVIEW application, control the state of inlet and outlet valves.

4 CONCLUSIONS

On the base of our experience in the educational process during the last five years it is possible to formulate following remarks:

- the animated presentations of DVIs (Demonstration Virtual Instruments) make lecture more attractive and provide facilities for better understanding presented problem,
- preparation to laboratory exercises based on VHLEM enables to understand better laboratory tasks and to have practice in manipulation of the instruments which are used during the sessions in the university laboratory.

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