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Integration of virtual instrumentation in marine electrical engineering education

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Abstract: *Virtual instruments have wide application and they are used not only for measurements and control but also as an excellent tool in engineering education. They can be utilized in real and actual laboratories. They present huge support for individual learning and distance learning. This paper presents an example of using virtual instruments in the education of future Electro Technical Officers, actually the present students enrolled in the study program of Marine Electrical Engineering at Faculty of Maritime Studies Kotor, University of Montenegro. With the aim of promoting practical exercises for the subject Ship's Measurements as a part of the undergraduate study of Marine Electrical Engineering, the paper proposes examples of laboratory exercises with belonging schemes of connection and experimental set up.*

Keywords: *engineering education; virtual instrumentation; practical teaching; ship's measurements; LabVIEW*

1. INTRODUCTION

A number of measurements of physical values (the process values) of non-electric values are carried out on a ship for the purpose of managing ship and ship processes. Among these measurements, of special importance are measurements of temperature, pressure, flow, and level [1]. Due to the importance of process measurements in shipping, the education of seafarers should be enhanced with the subjects dealing with ship measurements so that the students can get familiar with the modern methods of measurement and acquire the knowledge and skills for independent work and future career. Practical education is a significant domain of the education process and learning and has a significant impact on seafarers' education. Therefore, laboratory exercises are very important part of engineering education, especially in the field of the ship's measurements principles [2]. With the development of e-learning, there is a considerable need for new methods of organizing laboratory work that are being under examination [3]–[5].

Virtual instrumentation connects sensors, hardware, and software technology with the aim of creating flexible and sophisticated instruments for process control and measurements [6]–[9]. Virtual instrumentation has defined a methodology for projecting measurement instruments that use a standard computer of general purpose, special hardware components for acquisition and digital conversion of the signal, and computer programs that provide collection, process, sign, and display of signal at the computer [6]. This universality introduces one key feature of the virtual instruments, enabling the user to modify desired functions in order to fit the wide spectrum of applications.

A review of the literature shows that LabVIEW is one of the primary software in designing applications and analytical solutions in different fields in engineering technology and education, such as biomedical engineering [10], electrotechnics [11]–[13], chemistry and chemical engineering [14], physics [15], mechanical engineering [16] and other.

Virtual instrumentation has a great role in the teaching process [17], in different fields of science: mathematics, physics, chemistry, biology, etc., improves the research process and increases the base of knowledge in other domains [18]. It also enhances learning in the laboratory, reduces the risks of the laboratory equipment, and enables the approach to expensive laboratories via the Internet connection [19]. From the aspect of distance learning [20]–[22], virtual instrumentation can be used to improve engineering courses, and the fact that it can be used with the aim of simulation of a physical phenomenon, to generate signals and read the results in real time [23], [24].

The use of educational tools the personal computer (PC) in the laboratories has become common in many training centers providing courses in the domain of engineering and technology. The research was conducted with the aim of acquiring virtual tools that resemble real surroundings for the purpose of motivating students' work [25]–[29].

In this paper, virtual instrumentation will be applied for creating several laboratory exercises for the subject Ship's Measurements which is conducted at the Faculty of Maritime Studies Kotor, University of

Montenegro, at the study program Marine Electrical Engineering.

The designed laboratory exercises presented in this paper will contribute to a better understanding of the contemporary methods of measurements of the process values and acquiring the practical knowledge necessary in the process of seafarer's education.

The paper is composed of the following sections. The first section presents the introduction. In the second is shown the importance of measurements in the process of education of the future Electro Technical Officers through the introduction of the new laboratory exercises within the subject Ship's Measurements of the study program at the Faculty of Maritime Studies Kotor, University of Montenegro. The concept of virtual instrumentation is shown in section three. A review of the laboratory exercises is given in section four.

2. MARINE ELECTRICAL ENGINEERING EDUCATION

Nowadays, the Electro Technical Officer (ETO) role became one of the more and more popular professions in the maritime industry [30]. The role of the Electro Technical Officer is defined by changes in the Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) from 1978. with amendments added in 2010 (Table A-III/6 STCW) [31]. Electro technical officers are responsible for supervision of systems and components in the fields of electrical engineering, electronics, communications, automatic control, and other on board in order to increase the operational safety and efficiency of the ship under the supervision of the Chief Engineer.

The ETO officer is one of the most important roles on board modern ships, especially when it comes to the expertise of handling important and complex electrical and electronic systems, without which is not possible to process some of the basic operational functions of the ship itself. On contemporary passenger ships which are equipped with diesel electric propulsion, the list of responsibilities and tasks of the Electro Technical Officer is even greater because it is necessary to maintain: air conditioning and heating systems, computer and communication systems, elevators, electric propulsion motors, generators and high voltage motors, main switchboards with transformers and high voltage distribution, automatic alarm and monitoring system (Machinery Automation System - M.A.S.), propulsion and steering machinery with converters, emergency lighting converter and associated emergency batteries, UPSs with batteries, complex navigational and communication equipment, etc.

The role of the ETO onboard a ship is extremely important, bearing in mind the trends in the technology of the production and use of modern ships, as well as the fact that the important ship's functions are increasingly under the supervision of automation systems and even artificial intelligence.

Future ETO officers are being educated in the study program of Marine Electrical Engineering, Faculty of Maritime Studies Kotor, University of Montenegro [32]. Within the framework of this study program, students have the opportunity to gain proper knowledge in all areas of marine electrical engineering which is necessary for quality training of future ETO officers. In the education of ETO officers and preparation for work onboard a ship, a very important segment is a practice as well as practical exercises in high-voltage and electrotechnical laboratories. The integration of virtual instrumentation into the teaching process through the subject Ship's Measurements represents the improvement of practical teaching.

The objectives of the Ship's Measurements course are to familiarize students with basic electrical and electronic measurements and instrumentation, and also to show them the principles of basic non-electrical measurements of physical quantities such as temperature, pressure, flow, level, etc.

3. VIRTUAL INSTRUMENTATION

The application of the concept of virtual instrumentation is of exceptional importance in measurements. The creation of instruments "per measurements" gives users the possibility of wide applications, and a variety of sophisticated sensors, modern design technology, enable the application in different fields of science and technics. Its application has special importance in the education process.

The concept of virtual instrumentation refers to the transition from traditional hardware measurement devices to modern software-oriented measurement systems [6].

Virtual instrumentation is a concept meaning integration of hardware and software, encompassing the processes of measurement, acquisition, processing, and display of the obtained data, representing the trend in technics and science due to the rising complexity of engineering jobs, the growing need for specialized and sophisticated instruments and software solutions, as well as the need for highly skilled personnel for work with the instruments. The application ranges are from the simple laboratory experiments to the complex applications for automation purposes [6], [8].

The company National Instruments has implemented a specialized software package LabVIEW enabling the program devices that will perform the role as conventional measurement instruments where the complete analysis and data processing is simultaneously performed on the personal computer. Therefore, personal computer takes over the role of the conventional instrument whereas the graphical user interface programmed in LabVIEW may represent the real instrument and that's where it comes from the title virtual instrumentation [6].

The purpose of the virtual instrument is identical as the function of the classical instrument. The difference is that the virtual instrument may change and adapt to the measuring process compared to a classic instrument which has unchangeable functionality stated by the producer. Representation of measured data is usually in graphical form, functions, and controls, of a graphical interface that resembles real measurement instruments. The interface is active and has possibilities of the control of measurement process, defined by the signal parameters which are generated [6], [8]. The measurement-acquisition system based on PC computer is shown in Figure 1.

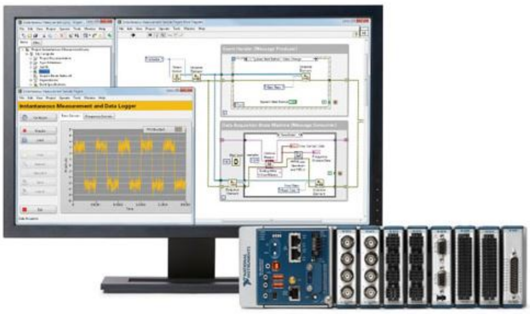

Figure 1. *Measurement- acquisition system based on PC computer* [33]

4. PERFORMING THE EXPERIMENTS

The laboratory exercises simply presented in this section show the application of virtual instrumentation in the implementation of practical classes in the field of ship's measurements. It is possible to easily create virtual instruments that enable the measurement of basic electrical and non-electrical quantities.

To implement the exercises, it is necessary to have a computer on which the LabVIEW software is installed, a power source, various sensors, acquisition cards etc. The advantage of such laboratory exercises is the simplicity of the hardware (DAQ-data acquisition, sensors, power supply) and the possibility of creating creative solutions in the LabVIEW program. The acquisition card (DAQ) is controlled via LabVIEW for generating and obtaining physical signals in the laboratory environment. The obtained results can be processed in different ways within the LabVIEW software package.

In this section, four laboratory exercises are presented, two for measurement of electrical quantities and two to the measurement of non-electrical quantities. Laboratory exercises 1 and 2 refer to the measurement of voltage and current. The goal of these laboratory exercises is to gradually introduce students to the use of virtual instrumentation, the connection of all elements in the measurement system, and especially the use of acquisition cards and the creation of virtual instruments through basic measurements in electrical engineering, which include current and voltage measurements. Laboratory exercise 3 shows temperature measurement. The goal of this exercise is to show students how to measure signals from thermocouples using a measuring system based on a PC. Mass measurement, including calibration of the measuring cell, is shown in laboratory exercise 4.

4.1. The laboratory exercise 1

A laboratory exercise related to voltage measurement is shown in this section.

To perform this laboratory exercise, the necessary equipment consists of an acquisition card NI 6009, a potentiometer (BK5), and an experimental board. The connection set up scheme of this laboratory exercise is shown in Figure 2.

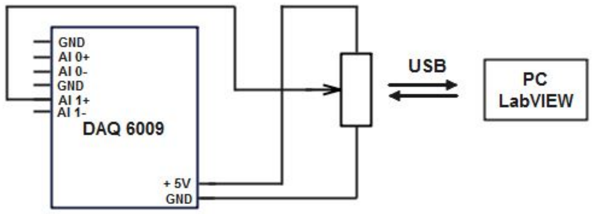

Figure 2. *Connection scheme for laboratory exercise of the voltage measurement*

First, it is necessary to connect the NI 6009 acquisition card to the computer via a USB cable. As shown in Figure 3, the potentiometer is connected to the experimental board. One end of the potentiometer is connected to the digital input of the acquisition card (GND), while the other end is connected to the digital input (+5V). The middle output of the potentiometer is connected to one of the analog inputs.

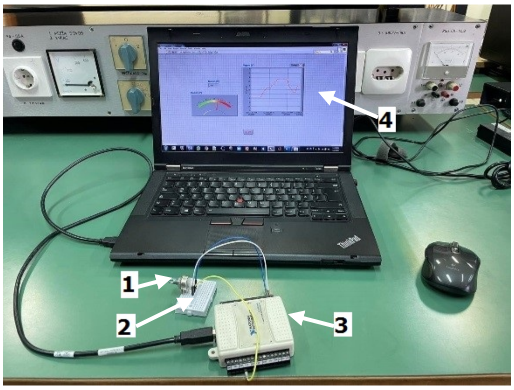

Figure 3. *Experimental set up for laboratory exercise of the voltage measurement*

In Figure 3, the following are marked with numbers:

1- potentiometer;

2- experimental plate;

3- acquisition card NI 6009, and

4- computer with installed LabVIEW software.

Front panel of the laboratory exercise related to voltage measurement in the LabVIEW 2021 software is shown in Figure 4.

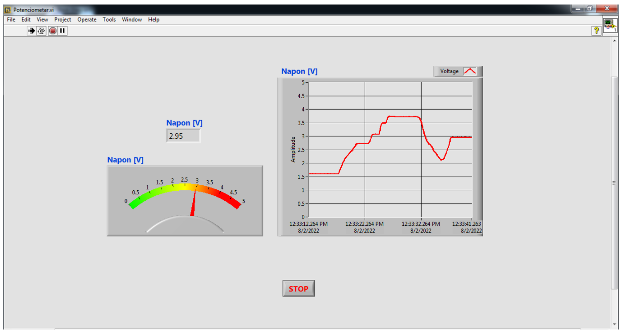

Figure 4. *Front panel of the laboratory exercise 1.*

4.2. The laboratory exercise 2

This section shows laboratory exercise related to the measurement of current through a shunt resistor.

To perform this laboratory exercise, the necessary equipment consists of an acquisition card NI 6009, a shunt resistor with power of 40 W and resistance of 1 Ω, and a light bulb with a power of 100 W. The connection scheme of this laboratory exercise is shown in Figure 5.

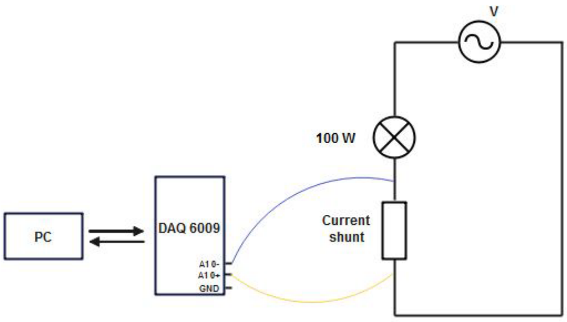

Figure 5. *Connection scheme for laboratory exercise of the current measurement*

The voltage from the autotransformer is applied to the serial connection of the light bulb and the shunt resistor (low resistance). An NI 6009 acquisition card is connected parallel to the shunt, which is connected to a computer via a USB cable, as it is shown in Figure 6.

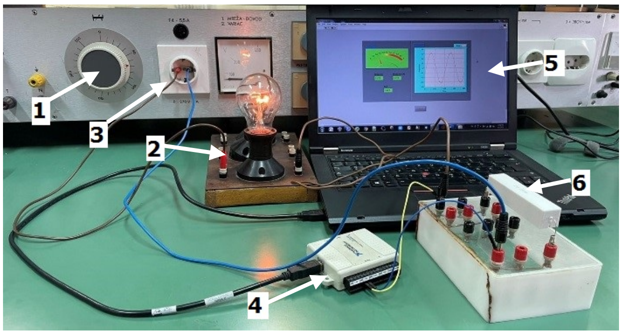

Figure 6. *Experimental setup for laboratory exercise of the current measurement*

In Figure 6, the following are marked with numbers:

1- autotransformer;

2- board with light bulb;

3- power supply;

4- acquisition card NI 6009;

5- computer with installed LabVIEW software and

6- shunt resistor.

Front panel of laboratory exercise 2 related to the measurement of current through a shunt resistor in the software LabVIEW 2021 is shown in Figure 7.

Figure 7. *Front panel of the laboratory exercise 2.*

4.3. The laboratory exercise 3

A huge number of non-electric quantities are measured on ships for the purposes of managing ship processes, among which a special place belongs to temperature measurements. There is a variety of temperature sensors which have application onboard, but the thermocouple is the most commonly used sensor for temperature measurement due to its low price, wide measurement range, ease of installation, and easy application [6], [13].

Thermocouples are based on the thermoelectric effect (Seebeck effect). According to the Seebeck effect, a voltage differential can be created between two electrical conductors or semiconductors by varying their temperatures. The Seebeck voltage depends on the type of material and the temperature difference between T_1 and T_2 (Figure 8) [17].

$$U_{AB} = K_A (T_2 - T_1) - K_B (T_1 - T_2) = \alpha (T_2 - T_1) \quad (1)$$

where K_A and K_B are the thermoelectric constants of two conductors, and the coefficient α is the thermoelectric Seebeck proportionality constant that depends on those two conductors [17].

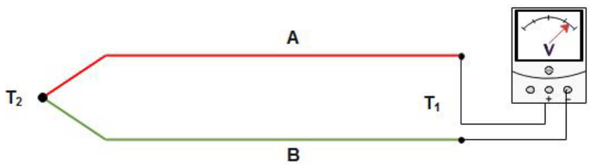

Figure 8. *Thermoelectric circuit* [13]

This section shows laboratory exercise related to temperature measurement.

In order to perform laboratory exercise related to the temperature measurement with a thermocoule, it is necessary to have the following equipment: a thermocouple (J type), a personal computer with

LabVIEW software and NI cDAQ-9178 chassis with an NI 9211 data acquisition card and two cups (with hot and cold water).

Experimental setup for temperature measurement is shown in Figure 9.

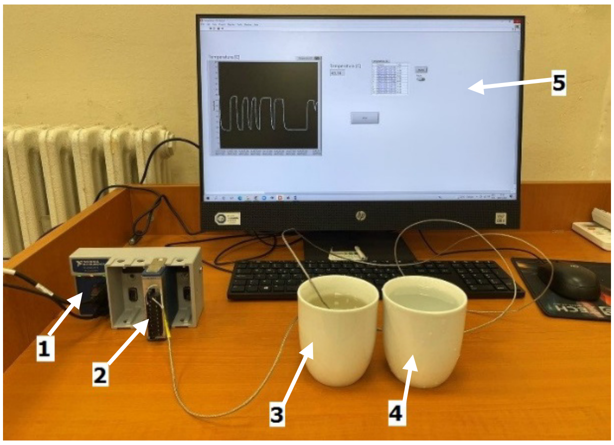

Figure 9. *Experimental setup for temperature measurement*

In Figure 9, the following are marked with numbers:

1- NI CompactDAQ Four-Slot USB Chassis (cDAQ-9174);

2- acquisition card NI 9211;

3- cup with hot water;

4- cup with cold water, and

5- computer with installed LabVIEW software.

In Figure 10 is shown the connection scheme for thermocouple binding with an acquisition card.

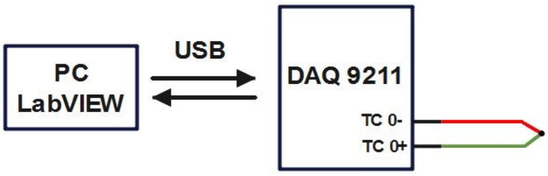

Figure 10. *Connection scheme for thermocouple binding with an acquisition card*

The process of temperature changes, increase and decrease, while the thermocouple is transferred from one cup to another, is monitored on the LabVIEW 2021 front panel shown in Figure 11. All measured temperatures are stored in Excel format and in this form gained results are ready for further processing.

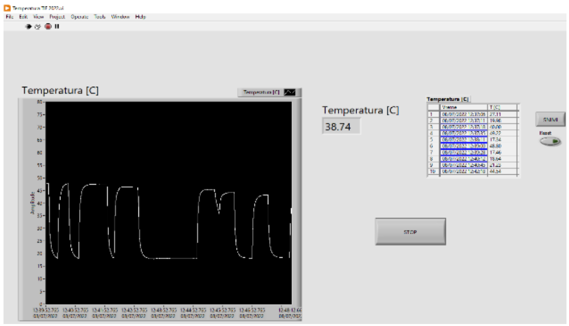

Figure 11. *Front panel of the temperature measurement in LabVIEW software*

4.4. The laboratory exercise 4

A laboratory exercise related to the mass measurements, including the calibration of load cell is shown in this section.

The load cell belongs to the group of resistance sensors for the load measurements. It is made of aluminum which is weakened in the middle part to enables elastic bending. Strain gauges are placed on the upper and lower sides. They are arranged so that two are placed on the top of the opening of the load cell, and two at the bottom [34]. This arrangement allows the strain gauge to be connected to the Wheatstone bridge circuit as shown in Figure 12.

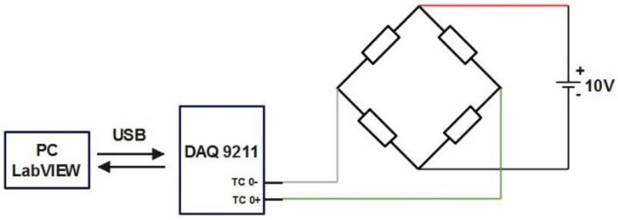

Figure 12. *Connection scheme of the measuring cell and acquisition card*

When the load cell is loaded, it bends, the strain gauge tightens and leads to a change in its resistance. Before starting the mass measurement with the load cell, it is necessary to determine its characteristic or clarify the relation between input and output quantities. This characteristic of the load cell with strain gauge represents the correlation between load cell output voltage and load itself. To determine this characteristic, it is necessary to calibrate the measuring cell. This procedure can be performed by measuring the output voltage U of the measuring cell for different values of the known mass m. In this way, the characteristic of the measuring cell is obtained as a set of measured points *(m, U)* [34].

Experimental setup for mass measurement is shown in Figure 13. The measuring system consists of a load cell (CZL602 3 kg), 10 V battery, NI-9211 data acquisition card manufactured by National Instruments, and load.

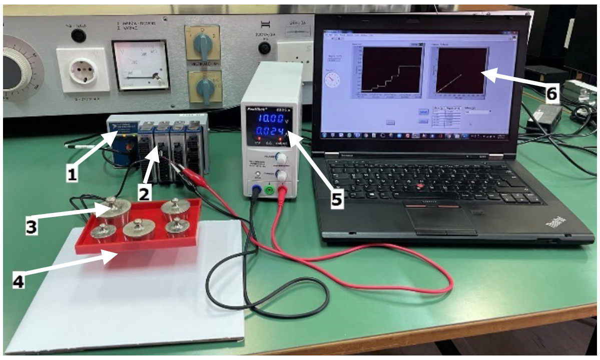

Figure 13. *Experimental setup for mass measurement*

In Figure 13, the following are marked with numbers:

1- NI CompactDAQ Four-Slot USB Chassis (cDAQ-9174);

2- acquisition card NI 9211;

3- load 50 to 500 [g];

4- load cell CZL608 3 kg;

5- 10 V battery, and

6- computer with LabVIEW software installed.

Figure 14 shows the calibration procedure. The beginning of the calibration starts with the measuring cell without load and this initial state must be recorded and output voltage must be measured. The measured output voltage will be of non-zero value due to system imperfections. It is possible to override this voltage by using the software. After the zero point for voltage measurement is set up, it is necessary to fill in the initial values in the table in the front panel of the LabVIEW software, which will be displayed graphically at the same time [34]. After this first step, it is necessary to add additional load to the measuring cell of 50 g and save the obtained results in the table. Each following load placed on the load cell should be greater than the previous one, and procedure should be carried out until the nominal load is exceeded. When the calibration is finished (by clicking the "Stop" button), the calibration program will be stopped.

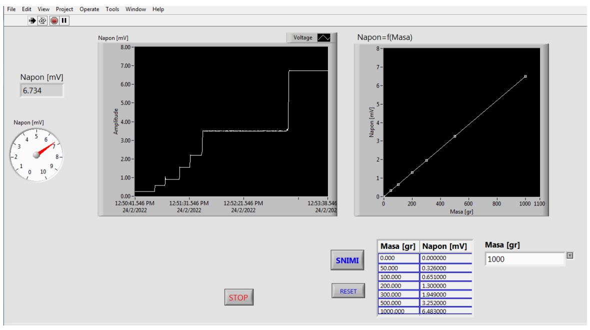

Figure 14. *Front panel of the laboratory exercise for load cell calibration in LabVIEW software*

After the calibration process, an application for measuring unknown masses was created and it is shown in Figure 15.

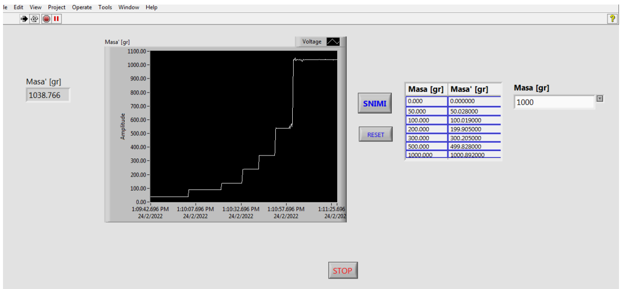

Figure 15. *Front panel of the laboratory exercise for measuring an unknown mass*

Numerical data of the load cell calibration is given in Table 1. Calibration has been performed for different loads up to 1000 g.

Table 1. *Measurement results of load cell calibration*

***m* [g]**	***U* [mV]**
0	0
50	0.326
100	0.651
200	1.300
300	1.949
500	3.252
1000	6.483

Using the created program, measurements were made with known masses and the measured deviations are presented in Table 2.

Table 2. *Results of measurement of mass and absolute and relative deviations*

***m* [g]**	***m′* [g]**	$\Delta m = \lvert m' - m \rvert$	$\delta m = \frac{\Delta m}{m} \cdot 100$ **[%]**
0	0	0	0
50	50.028	0.028	0.056
100	100.019	0.019	0.019
200	199.905	0.095	0.047
300	300.205	0.205	0.068
500	499.828	0.172	0.034
1000	1000.892	0.892	0.089

CONCLUSION

The paper presents a few examples of laboratory exercises that represent the beginning of the application of virtual instrumentation in the teaching process at Faculty of Maritime Studies Kotor. These exercises represent the improvement of practical teaching within the subject Ship's Measurements. The schemes and the experimental setup for four laboratory exercises related to voltage measurement, current measurement, temperature measurement with thermocouples and mass measurement with the previous calibration of the measuring cell are presented.

Future directions of research refer to the creation of virtual instruments for more complex temperature measurements on one of the systems used on board ships, as well as the survey students' satisfaction with this type of experiments.

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REFERENCES

[1] N. Barjamović, *Brodska mjerenja*. Kotor: Fakultet za pomorstvo, Univerzitet Crne Gore, 2006.

[2] T. Dlabac, A. Milovanovic, B. Koprivica, M. Calasan, and M. Janjić, 'Evaluation of internet-based practical teaching in higher education', presented at the International Scientific Conference - UNITECH 2019, Gabrovo, Bulgaria, Nov. 2019.

[3] B. Popović, N. Popović, D. Mijić, S. Stankovski, and G. Ostojic, 'Remote Control of Laboratory Equipment for Basic Electronics Courses: A LabVIEW-Based Implementation', *Comput. Appl. Eng. Educ.*, vol. 21, Aug. 2013, doi: 10.1002/cae.20531.

[4] N. M. Avouris, N. Tselios, and E. C. Tatakis, 'Development and evaluation of a computer-based laboratory teaching tool', *Comput. Appl. Eng. Educ.*, vol. 9, no. 1, pp. 8–19, 2001, doi: 10.1002/cae.1001.

[5] M. Stefanovic, V. Cvijetkovic, M. Matijević, and V. Simic, 'A LabVIEW-Based Remote Laboratory Experiments for Control Engineering Education', *Comput. Appl. Eng. Educ.*, vol. 19, pp. 538–549, Sep. 2011, doi: 10.1002/cae.20334.

[6] A. Milovanović, M. Bjekić, and B. Koprivica, *Virtuelna instrumentacija*. Fakultet tehničkih nauka u Čačku, Univerzitet u Kragujevcu, 2010.

[7] A. S. Morris, *Measurement and instrumentation principles*. Oxford [England] ; Boston: Butterworth-Heinemann, 2001.

[8] J. Jerome, *Virtual instrumentation using LabVIEW*. PHI Learning Pvt. Ltd., 2010.

[9] T. Bress, *Effective LabVIEW Programming*. 2013.

[10] H. A. Modran, D. Ursuțiu, C. Samoila, and T. Chamunorwa, 'Intelligent IoT Biomedical Bluetooth Data Acquisition System', in *New Realities, Mobile Systems and Applications*, Cham, 2022, pp. 970–979. doi: 10.1007/978-3-030-96296-8_88.

[11] B. Koprivica and A. Milovanovic, 'Application of virtual instrumentation in determination of AC magnetic properties of electrical steel sheet under DC-biased magnetization', presented at the International Scientific Conference "UNITECH 2014", Gabrovo, Bulgaria, Nov. 2014.

[12] B. Koprivica, M. Sucurovic, N. Jevtić, and A. Milovanovic, 'Measurement of magnetic flux density of large-diameter multilayer solenoid', presented at the 13th International Conference on Applied Electromagnetics – ПЕС 2017, Nis, Serbia, Aug. 2017.

[13] B. Koprivica, A. Milovanovic, and T. Dlabac, 'An approach to cold junction compensation and identification of unknown thermocouple type', *Rev. Roum. Sci. Tech. - Ser. Électrotechnique Énergétique*, vol. 63, pp. 277–282, Sep. 2018.

[14] E. E. Tereshatov *et al.*, 'Compact automated apparatus for rapid astatine recovery from nitric acid media: Design, application, and impurity characterization', *Chem. Eng. J.*, vol. 442, p. 136176, Aug. 2022, doi: 10.1016/j.cej.2022.136176.

[15] C. L. Rat, C. I. Ichim-Burlacu, and C. Panoiu, 'Modeling the synchronous permanent magnet generator with RLC load', *J. Phys. Conf. Ser.*, vol. 2212, no. 1, p. 012019, Feb. 2022, doi: 10.1088/1742-6596/2212/1/012019.

[16] J. W. Frazer, A. Karimi, A. C. Rogers, and T. J. Connolly, 'Computer-assisted Laboratory Experience in an Undergraduate Mechanical Engineering Program', presented at the 2002 GSW, Mar. 2022. Accessed: May 24, 2022. [Online]. Available: https://peer.asee.org/computer-assisted-laboratory-experience-in-an-undergraduate-mechanical-engineering-program

[17] A. Milovanović and B. Koprivica, *Laboratorijski praktikum iz električnih merenja: Merenje neelektričnih i magnetskih veličina- I deo*. Čačak: Fakultet tehničkih nauka u Čačku, Univerzitet u Kragujevcu, 2021.

[18] L. V. Alexeychik, M. P. Zhokhova, D. V. Mikheev, and M. V. Karpunina, 'Electrotechnical Laboratory: From Physical Experiment to Virtual Scenario', in *2018 IV International Conference on Information Technologies in Engineering Education (Inforino)*, Oct. 2018, pp. 1–4. doi: 10.1109/INFORINO.2018.8581853.

[19] I. Garović, B. Koprivica, and A. Milovanović, 'Primena virtuelne instrumentacije u realizaciji labaratorijskih vežbi iz oblasti električnih merenja', Čačak, Jun. 2011, pp. 1–9.

[20] X. Chen, G. Song, and Y. Zhang, 'Virtual and Remote Laboratory Development: A Review', Mar. 2010, doi: 10.1061/41096(366)368.

[21] B. Gergič, D. Hercog, L. Mikola, and V. Matko, 'Using the Internet and Virtual Instrumentation to enhance the learning of Electrical Measurements', Jan. 2004.

[22] P. Trentsios, M. Wolf, and S. Frerich, 'Remote Lab meets Virtual Reality – Enabling immersive access to high tech laboratories from afar', *Procedia Manuf.*, vol. 43, pp. 25–31, Jan. 2020, doi: 10.1016/j.promfg.2020.02.104.

[23] Y. Ugurlu, 'Measuring the impact of virtual instrumentation for teaching and research', in *2011 IEEE Global Engineering Education Conference (EDUCON)*, Apr. 2011, pp. 152–158. doi: 10.1109/EDUCON.2011.5773129.

[24] C. Dumitrescu, R. L. Olteanu, L. M. Gorghiu, G. Gorghiu, and G. State, 'Using virtual experiments in the teaching process', *Procedia - Soc. Behav. Sci.*, vol. 1, no. 1, pp. 776–779, Jan. 2009, doi: 10.1016/j.sbspro.2009.01.138.

[25] G. Ramachandiran, J. Kandhasamy, and A. Saminathan, 'Virtual Instrumentation in Electrical Engineering Applications', *J. Inst. Eng. India Ser. B*, vol. 101, no. 2, pp. 193–199, Apr. 2020, doi: 10.1007/s40031-020-00437-w.

[26] H. A. Malki and A. Matarrita, 'Web-based control systems laboratories using LabVIEW', vol. 20, pp. 22–25, Mar. 2003.

[27] J. Trevelyan, 'Lessons learned from 10 years experience with remote laboratories', pp. 1562–3580, Jan. 2004.

[28] T. L. Schwartz and B. M. Dunkin, 'Facilitating interdisciplinary hands-on learning using LabVIEW', *Int. J. Eng. Educ.*, vol. 16, no. 3, pp. 218–227, 2000.

[29] W. Rui, X. Rui, and L. Hui, 'Design and application of LabVIEW courseware in the signal processing teaching', in *2012 7th International Conference on Computer Science & Education (ICCSE)*, Jul. 2012, pp. 1365–1368. doi: 10.1109/ICCSE.2012.6295317.

[30] M. Dževerdanović-Pejović and T. Dlabac, 'The Challenges Of Teaching English To The Marine Electrical Engineering Students', 2021, pp. 101–108. doi: 10.53656/pcd21.

[31] T. Dlabač, M. Dževerdanović-Pejović, J. Nikčević, and V. Kapetanović, 'THE IMPORTANCE OF MARITIME EDUCATION AND TRAINING QUALITY CONTROL: THE CASE OF MONTENEGRO', presented at the 20th International Conference on Transport Science, ICTS 2022, Portoroz, Slovenia, May 2022.

[32] Š. Ivošević *et al.*, *Pomorski fakultet Kotor = Faculty of Maritime Studies Kotor*. Kotor : Univerzitet Crne Gore, Pomorski fakultet Kotor, 2019.

[33] 'Data Acquisition | STABILITY'. https://www.stability.co/data-acquisition/ (accessed Jul. 07, 2022).

[34] S. Milosavljević, A. Milovanovic, and B. Koprivica, 'Virtual Instrumentation for Load Cell - Calibration and Measurements', presented at the International Scientific Conference Technics and Informatics in Education, May 2018.