

A CONTRIBUTION TO APPLICATION OF NI LABVIEW SYSTEM IN INVESTIGATION OF TIRE-TERRAIN INTERACTIONS

PRÍSPEVOK K APLIKÁCII SYSTÉMU NI LABVIEW VO VYŠETROVANÍ KONTAKTU PNEUMATIKY A TERÉNU

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ABSTRACT: The paper deals with a solution of NI LabVIEW system for investigation of tire-terrain interactions, with focus on detailed description of a measurement technique and LabVIEW system. A mechanical basis on which the measurement system is based was designed as laboratory measuring stand. A purpose of the work is to show how such a measurement system can be built and what is needed to make it done. Presented measurement system, as a result of the work, consists of several NI transducers connected with a laptop via USB. Test results and experiences with the measurement system verified that prototype of the system is usable and it can be used for investigation of tire-terrain interactions.

Keywords: Tire-terrain interaction, LabVIEW, measuring stand

ABSTRAKT: Článok sa zaoberá riešením aplikácie systému NI LabVIEW pre vyšetrovanie interakcií medzi terénom a pneumatikou s dôrazom na detailný popis meracej techniky a LabVIEW systému. Mechanický základ na ktorom je merací systém postavený bol navrhnutý ako laboratórny merací stend. Účelom práce je ukázať ako takýto merací systém môže byť postavený a čo je na to potrebné. Prezentovaný merací systém, ako výsledok práce, sa skladá z niekoľkých NI prevodníkov pripojených k notebooku cez USB rozhranie. Výsledky testov a skúsenosti s meracím systémom potvrdili, že prototyp systému je použiteľný a môže byť použitý pre vyšetrovanie interakcií medzi pneumatikami a terénom.

Kľúčové slová: Interakcia pneumatiky a terénu, LabVIEW, merací stend

1. INTRODUCTION

There are many ways how to measure physical parameters of technical systems. The most of them use some measuring devices with displays and controls built-in in hardware of the devices. A general measuring device uses its inputs to measure values of electrical signals and outputs to display or provide processed signals. A transformation between physical parameters and required electrical signal is done via transducers and modules, which have, in many cases, form of extending cards dependent on main chassis of the device. Below described application of the National Instruments (NI) LabVIEW system uses different approach - graphical system design.

The application of the system is described on a laboratory soil canal developed and manufactured on the Department of Forest and Mobile Technology.

2. MATERIALS AND METHODS

Competing in today's global economy requires companies to rapidly enter the market with innovative products that offer increased functionality and operate flawlessly. The National Instruments graphical system design approach for test, control, and embedded design meets this need by providing a unified platform for designing, prototyping, and deploying applications. The NI platform empowers engineers to integrate real-world signals sooner for earlier error detection, reuse code for maximum efficiency, benefit immediately from advances in computing technology, and optimize system performance in a way that outpaces traditional design methodologies. [1]

LabVIEW is a program development application, much like various commercial C or BASIC development systems, or National Instruments LabWindows. However, LabVIEW is different from those applications in one important respect. Other programming systems use text-based languages to create lines of code, while LabVIEW uses a graphical programming language, G, to create programs in block diagram form. [2]

LabVIEW has extensive libraries of functions and subroutines for most programming tasks. For Windows, Macintosh, and Sun, LabVIEW contains application specific libraries for data acquisition and instrument control. LabVIEW also contains application-specific libraries and serial instrument control, data analysis, data presentation, and data storage. LabVIEW includes conventional program development tools, so it is possible to set breakpoints, animate program execution to see how data passes through the program, and single-step through the program to make debugging and program development easier. [2]

LabVIEW includes libraries of functions and development tools designed specifically for instrument control. LabVIEW programs are called virtual instruments (VIs) because their appearance and operation imitate actual instruments. However, they are analogous to functions from conventional language programs. VIs have both an interactive user interface and a source code equivalent, and accept parameters from higher-level VIs. The following are descriptions of these three VI features: [2]

- VIs contain an interactive user interface, which is called the front panel (Fig.1), because it simulates the panel of a physical instrument. The front panel can contain knobs, push buttons, graphs, and other controls and indicators. Input data are typed using a keyboard and mouse, and the results can be viewed on a computer screen,
- VIs receive instructions from a block diagram, which designer constructs in G language. The block diagram supplies a pictorial solution to a programming problem, so the block diagram contains the source code for the VI,
- VIs use a hierarchical and modular structure. It can be used in top-level programs, or as subprograms within other programs or subprograms. A VI within another VI is called a subVI. The icon and connector pane of a VI work like a graphical parameter list so that other VIs can pass data to it as a subVI. [2]

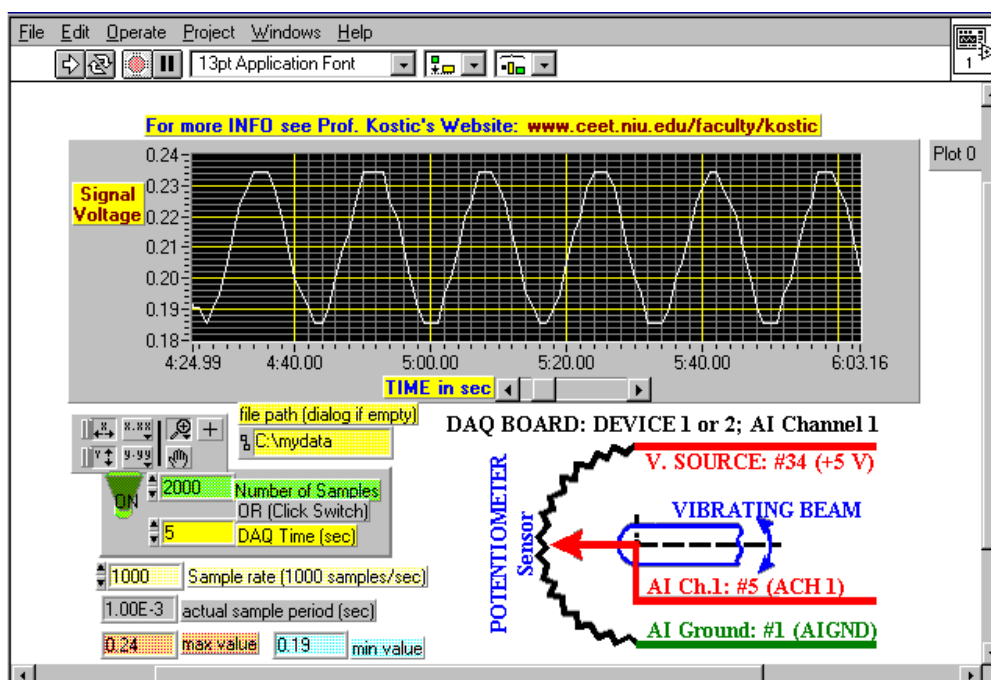


Figure 1 – An example of a LabVIEW's Front Panel [3]

With these features, LabVIEW promotes and adheres to the concept of modular programming. It is possible to divide an application into a series of tasks, which can be divided again until a complicated application becomes a series of simple subtasks. Simple VIs can be build to accomplish each subtask and then they can be combined on another block diagram to accomplish the larger task. Finally, a top-level VI contains a collection of subVIs that represent application functions. [2]

The application of LabVIEW on the soil canal (Fig.2 and 3) was carried out using below listed NI components (Tab.1).

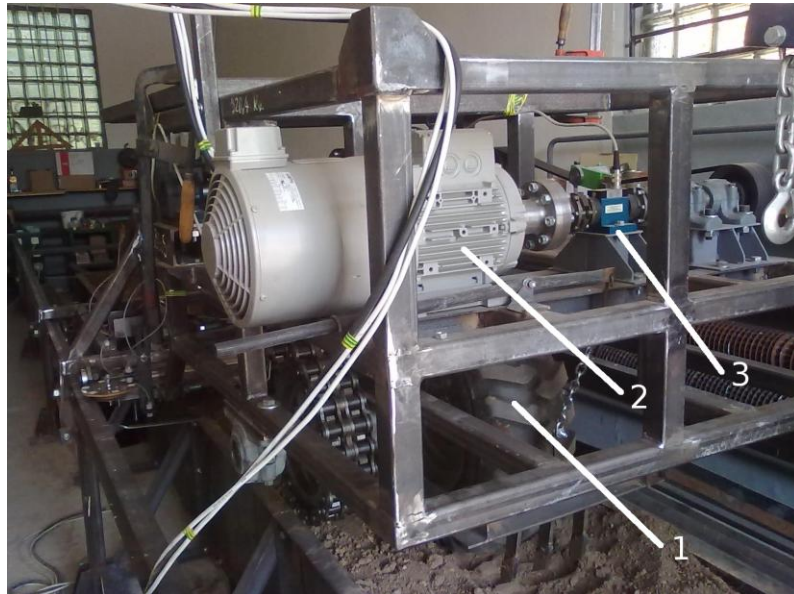


Figure 2 – Measuring stand for investigation of tire-terrain interactions. 1 – tire of carriage, 2 – electric motor, 3 – torque transducer DR 2212 R by ESA MESSTECHNIK GMBH

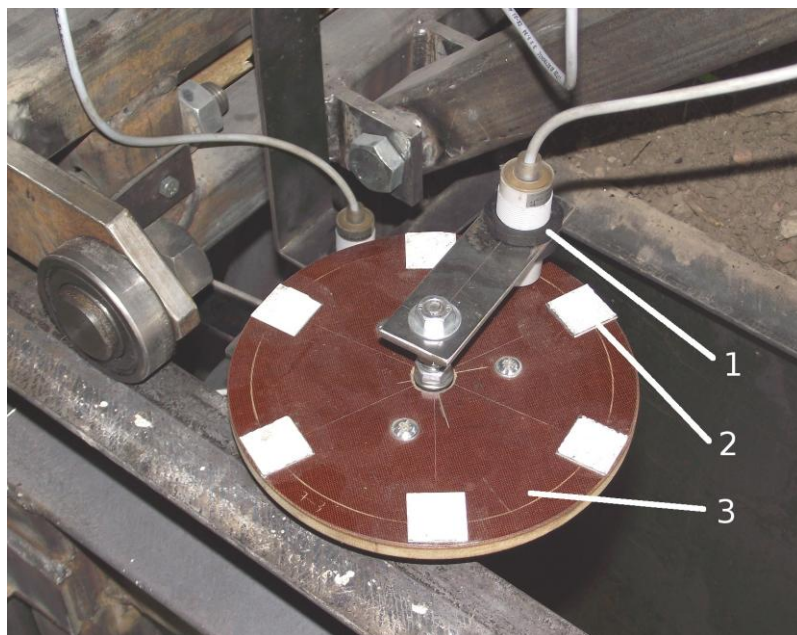


Figure 3 – Application of inductive sensor by Senzortech s.r.o. 1 – inductive sensor, 2 – steel plate, 3 – rotational disc made of plastic mounted on the wheeled frame of the carriage and strained against the static frame of the stand via rubber wheel underneath the disc (3).

The NI – 9215 input module we used to collect all of the signals. To perform computations within LabVIEW G-code we measured rotational speed of the electric motor (Fig.2), and rotational speed of the tire (Fig.2). As a supplemental value a torque was measured. To get real speed of the tire we used inductive sensor (Fig.3) and its output signal we processed in LabVIEW.

3. RESULTS

To measure, process and store data we designed and created a custom application in LabVIEW. This a main result presented in the paper. Its front panel is shown in Fig.4.

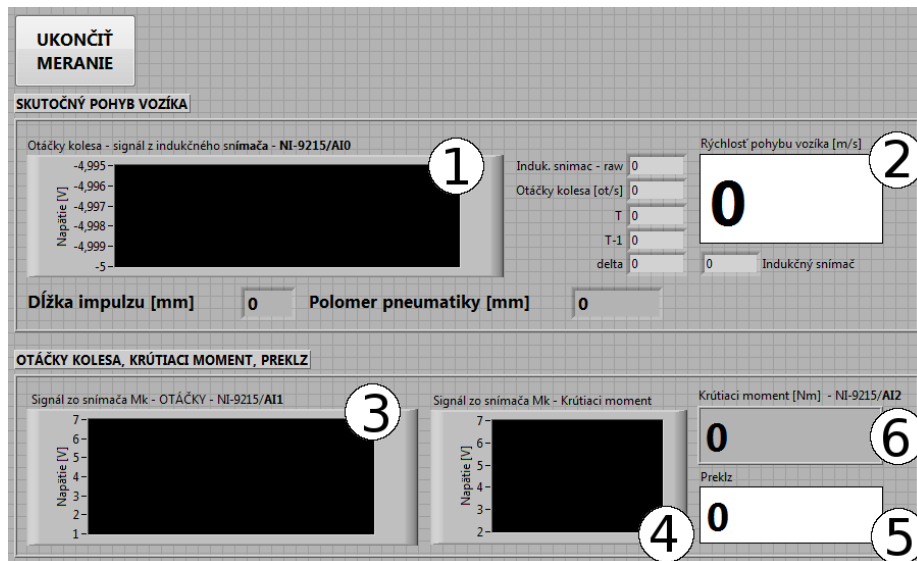


Figure 4 – Front panel of the custom LabVIEW application. 1 – Chart of raw signal from inductive sensor, 2 – instant translational speed of wheeled chassis [m/s], 3 – chart of rotational speed values of the tire, 4 – chart of torque values, 5 – instant longitudinal slip of the tire [%], 6 – instant value of torque [Nm]

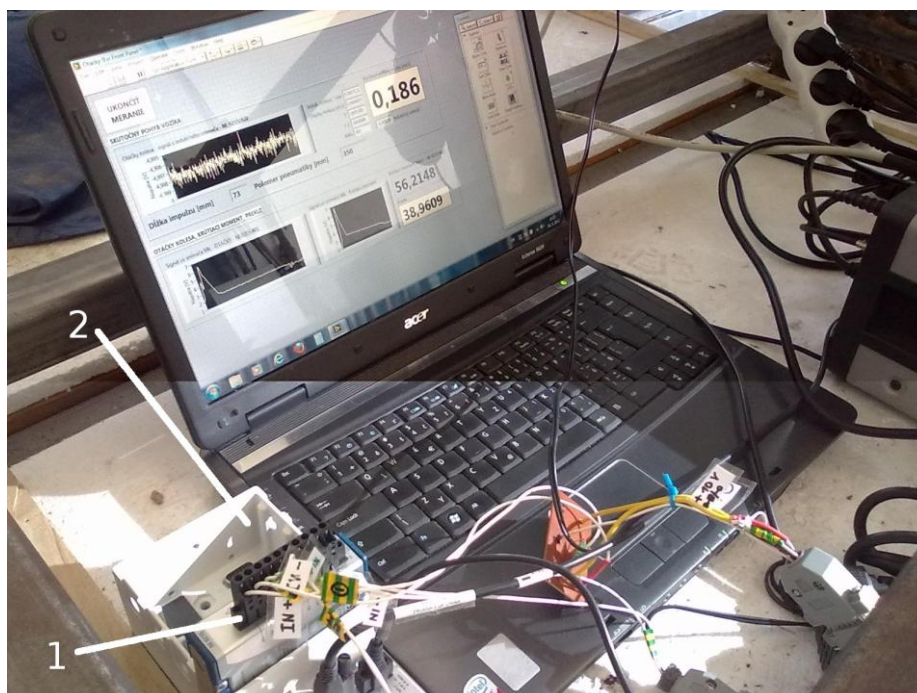


Figure 5 – Measuring stand with NI cDAQ-9174 chassis (2) and NI 9215 module (1)

As a part of the solution an electric circuit, used for connection of the inductive sensor, was designed and manufactured. The rotational disc (Fig.3) we used for carriage translational speed measurements.

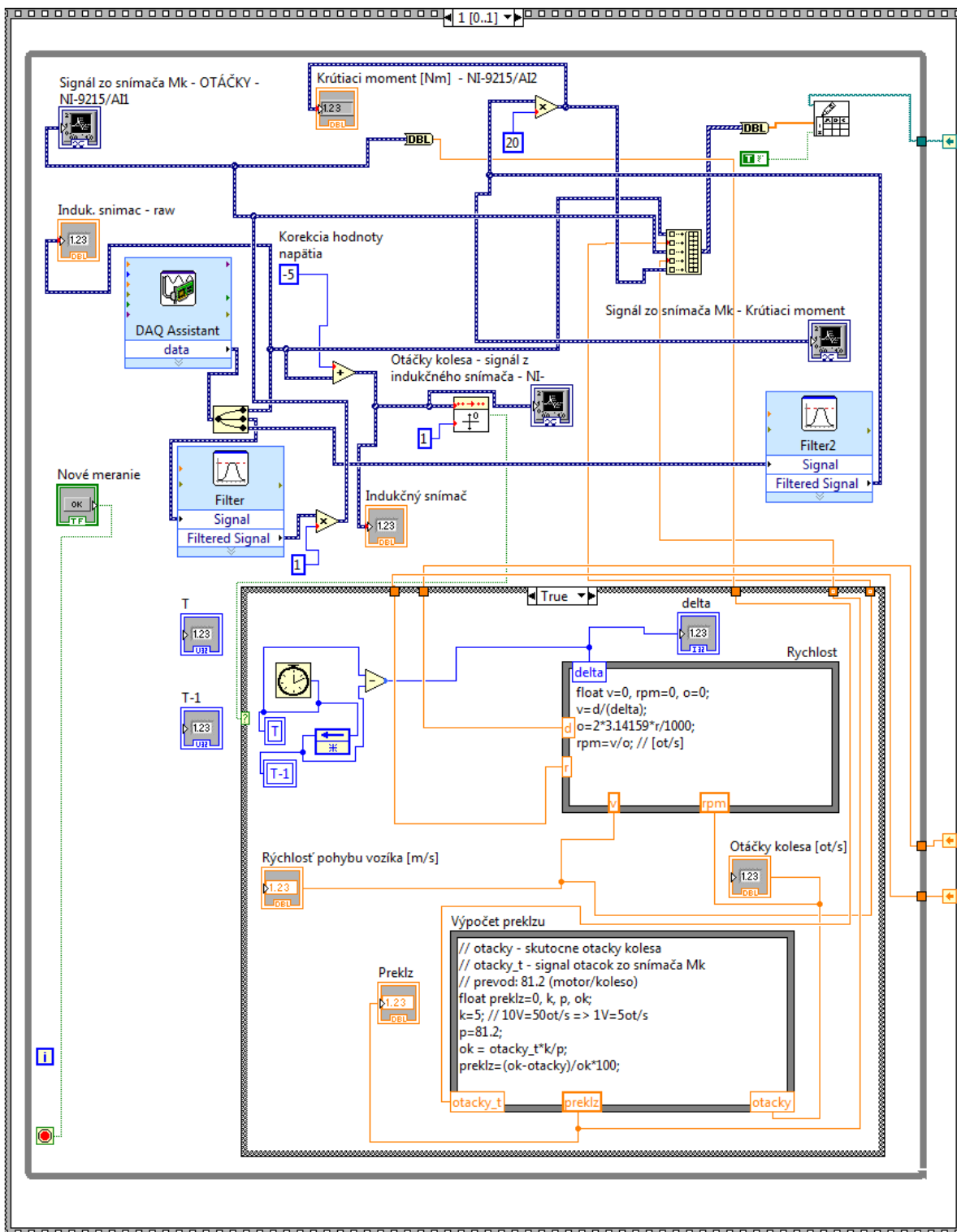


Figure 6 – Created block diagram corresponding to front panel shown in Fig.4.

As it can be seen in Fig.6, it is simple to make an input/output signal filtered. Measured values were processed using LabVIEW and its Formula Node, as it is shown in

Fig.6. A typical square wave output signal of the inductive sensor we processed using a zero-crossing function, as it is visible in a case structure (see a clock icon) in Fig.6. We found no issues regarding that and overall solution herein presented.

A function of the measurement system was verified. We performed a few of test measurements, which allow us to declare that the system is fully usable. The use of LabVIEW enabled us to measure and process data from the stand, however it can be done by any another measuring system. The difference is in a visualisation level of the measurement and in its overall approach to data processing – G language. The front panel shown in Fig.4 illustrate a custom view of a custom “measuring device”. This panel can be displayed on a touch screen and it can integrate the knobs, push buttons, graphs, and other controls and indicators which are needed for a particular measurement. A chassis, its modules, a computer or a real-time platform and supporting circuits can be placed in a sealed “black box” with the touch screen mounted on the side of that box. Such a solution does not require a user to be experienced in work with a classical complex measurement system; the all she/he needs is displayed and ready to use.

4. CONCLUSION

The paper was aimed on the LabVIEW use and its description. As a base for measurements was used the measuring stand designed for investigation of tire-terrain interactions, which description is a part of another paper. Using LabVIEW it is able to observe instant values of measured parameters in well-arranged form, designed for the specific purpose. This is one of main benefits of the system. Results were written directly into a spreadsheet table, and ready for MS Excel processing. According to G-language possibilities a measuring system can be built up with respect to all customer needs, and requirements, so a particular measuring process can be well optimized, ready to use and business.

SÚHRH

Článok sa zameria na zrealizovaný prípad použitia systému LabVIEW a jeho popis. Ak základ na merania bol použitý stend navrhnutý pre výskum interakcií medzi pneumatikou a terénom, ktorého popis je časťou iného článku. S použitím LabVIEW je možné sledovať okamžité hodnoty meraných parametrov v prehľadne zobrazenej forme, navrhutej pre tento účel. Toto je jedna z hlavných výhod systému. Výsledky boli zapisované priamo súboru vo forme tabuľky a takto pripravené pre spracovanie v aplikácii MS Excel. Vzhľadom na možnosti G-jazyka, merací systém môže byť zostavený s rešpektovaním všetkých potrieb a požiadaviek zákazníka, takže merací proces môže byť dobre optimalizovaný a pripravený na použitie a komerčné zhodnotenie.

ACKNOWLEDGMENTS

The work presented here was supported by national grant agency VEGA under grant No. 1/0048/09

APPENDIX

Table 1 – List of used NI components

Component's identification	Description
NI cDAQ-9174	NI CompactDAQ 4-Slot USB Chassis for hot-swappable I/O modules
NI – 9215	4-Channel, 100 kS/s/ch, 16-bit, ± 10 V Analog Input Module
NI LabVIEW 2009	A program development application

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