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CAPACITIVE C AND RC SENSORIAL TEST SYSTEMS FOR AUTOMATIC LIGHTING CONTROL

BY

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Abstract. In this article the authors propose an automatic lighting system using piezoelectric sensors. A software algorithm for identifying of the direction of movement (entry or exit of the laboratory) of a person is proposed. This algorithm identifies the order in which two piezoelectric sensors are operated. The proposed system for automating light control has two functions: reducing energy consumption in a hospital and avoiding of touching by people of possibly infected or dirty surfaces.

Keywords: LabVIEW; acquisition board; automation; piezoelectric sensors; health systems.

1. Introduction

The objective of this work was the development of a system for acquisition, processing and monitoring of vibrations using the virtual instrumentation developed in the graphic programming environment LabVIEW (Laboratory Virtual Instrument Engineering Workbench). The aim was to obtain a low-cost system. The hardware components of this low-cost system include vibration sensors, a signal conditioning circuit (a resistance) for the sensors, a data acquisition device (NI USB-6001 acquisition board) and a PC. The

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"LabVIEW Sound and Vibration Toolkit" from the graphical programming environment LabVIEW will be used because it has a number of predefined tools that implement a very powerful mathematical device. FFT is a very powerful instrument in the field of frequency for vibration signal analysis and provides the information about the frequency at which the defect occurs. For FFT analysis; it is necessary to transform vibration's data (dynamic data 100 mv/g) into the EU (engineering units), such as acceleration, speed and displacement.

Piezoelectric sensors are used for the applications of low frequency vibration measurements. When these sensors are selected correctly, they can generate enough power to be measured or further used. Compared to other types of sensors, piezoelectric sensors have the widest dynamic range in terms of frequency and amplitude (Ganeshkumar *et al*., 2007).

The traditional vibration test system that includes a single function measurement instrument has quite weak reliability and high costs. This represents the main disadvantages for such kind of instruments (Bhuvana *et al*., 2018).

Virtual instrumentation is a set of concepts and technologies that allows the interaction of an user with a virtual environment simulated by a computer. Virtual instrumentation is an interdisciplinary field that combines mechanical, electronic, automatic and robotics engineering, information technologies, physics, medicine, and human factors. By integrating the tool inside the computer, the user has full control over the computer, software application and tools that are created. Using the architecture of a virtual system of Digital Measurement Systems, users can choose low-cost boards with poor acquisition properties or with the possibility of stimulus and creating the rest through software. In addition, modular software technology such as Active X and Interchangeable Virtual Tools allow the user to build virtual tools. The graphical development environment such as LabVIEW takes full advantage of the benefits of modular software and allows the user to create tools by their choice (regardless of the hard platform or interface bus). The continuous evolution of the technology of the analog to digital converters, of the devices with basic computers and the data acquisition boards continues to compete with the stand-alone devices. Because Digital Measurement Systems take full advantage of the latest trends in analog to digital converter and PC technology, the costs of such a system are falling down.

An example for the method of testing and monitoring of the vibrations using the virtual instrumentation presented in the literature is by comparison with an accelerometer (Shah *et al*., 2013). The data was acquired with various acquisition boards, and then processed on a computer using various graphical programming environments containing powerful signal processing tools, such as: LabVIEW, MATLAB, etc.

On the other hand, lighting plays an important role in the analysis and treatment laboratory of a hospital. These spaces are have to be environmentally and functionally suitable for three groups of people: patients, hospital professionals and visitors. Also, lighting is considered a major consumer of electricity and therefore, during the designing of hospital lighting visual performance, visual comfort and energy efficiency should be taken into the account (Alzubaidi *et al*., 2012).

Studies have been done and critical areas have emerged in which the color and intensity of light can be used and applied for the benefit of all patients and employees. Thus, adjusting the optimal color contrast for the visually impaired, color levels, and number of lux in workspaces or areas designed for patients awaiting intensive treatment have been shown to be beneficial (Rizzo *et al*., 2010; Dalke *et al*., 2006). It has been found that a well-balanced and attractive environment is of major importance for the health of patients and staff.

With the development of the Internet, various autonomous or remote controlled automatic systems have been developed to optimize energy consumption or avoid touching certain elements by unauthorized persons. The Internet of Things (IoT) is a system of computers, sensors and various digital devices, spread all over the globe on the Internet, that can communicate with each other to share and transfer information using a unique ID that is assigned to each device. At present, these lighting systems can be ordered via the Internet, but they require a permanent Internet connection, as well as the operation of various control devices such as smart phones, remote control, bluetooth connection, etc.

The presented measurement process includes next steps: signal acquisition using NI USB-6001 acquisition board, signal preprocessing and signal analysis in both frequency and time domain. The entire measurement process is performed in a loop.

When designing the software, the sampling part should be carefully prepared. Shannon's theorem must be respected, but if the sampling rate is high the number of samples increases proportionally. Increasing the number of samples leads to increased processing time and in the end it is possible that the system can no longer work in real time. In the frequency and time analysis step, the frequency and time response of the sensor to different types of stimulus is analyzed. Mechanical and electrical stimuli were used. Electrical stimulus are represented by different types and values of the voltage applied to the sensor terminals (Hua *et al*., 2009).

2. Sensorial Test Systems Structure

The idea and the schematic diagram of the assembly is shown in Fig. 1.

Two PPA 1012 piezoelectric sensors connected in parallel with two resistors are used in order to obtain the output signal: a very small value when the sensor is not activated and a higher value when the sensor is activated. Thus two RC circuits have to be used.

The signal is acquired using the NI-USB 6001 data acquisition board. Analog inputs AI0 and AI1 have been used. The digital output DO0 and port P0.x were used to control the light on/off power circuit.

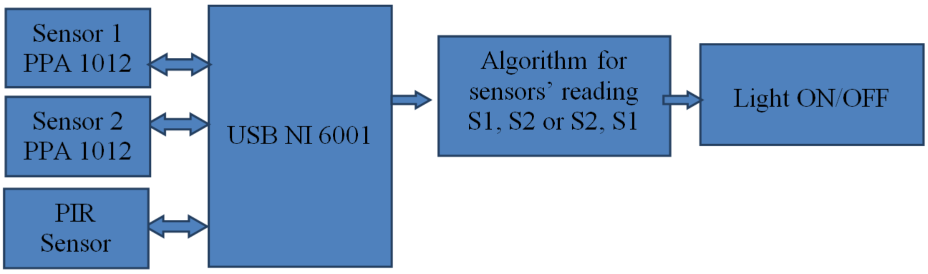

Fig. 1 – Schematic diagram of the assembly.

The application is useful in those areas where it is necessary to turn on / off the light without human intervention (for example: medical laboratories). The sensors are placed as follows: one in the hallway outside the room (sensor 1) and a second sensor inside the room immediately behind the door (sensor 2).

In Fig. 2 it is shown how to connect the sensors to the acquisition board.

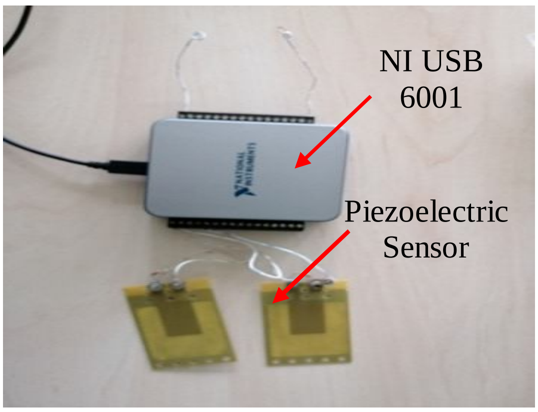

Fig. 2 – Sensors to the acquisition board.

3. Application used for Sensorial Test Systems

The front panel of the virtual instrument is shown in Fig. 3.

There can be two cases:

– Light on. In this case the order in which the sensors must be activated is Sensor 1 – Sensor 2. Sensor 1 is activated first. In this situation the signal is transformed. Using a threshold value, the signal is transformed in a digital one of logical value 1. This signal is stored for 5 seconds, while waiting for the output signal from the second sensor. If this signal appears within 5 seconds, during which time it is assumed that the man passes the other side of the door, the analog signal is transformed into a digital signal with the value of 1 logic. Having these two sensors activated in that specific order: Sensor 1 – Sensor 2, with the help of a logic gate of type "AND" (software gate), the digital output is

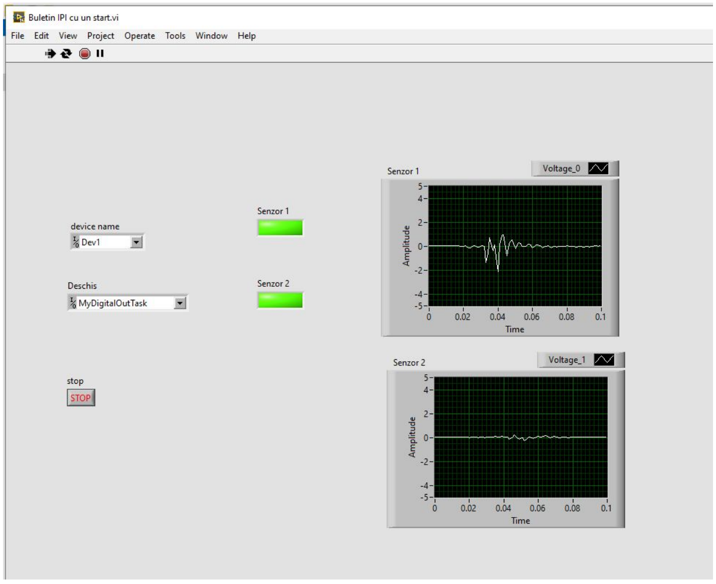

Fig. 3 – The front panel of the virtual instrument for the case „Light on”.

activated, being assigned with 1 logic. Activating the output will control the light ignition circuit. This state will be memorized and the digital output will remain in 1 logic until the second case is activated, turning the light off. In Fig. 2 can be seen the appearance of the signal from Sensor 1 and then with a delay the appearance of the signal from Sensor 2. The logical signal from the output is maintained for an indefinite period until the second case appears. At the same time, a counter will be implemented and the number of activations in this order (Sensor 1 – Sensor 2) will be stored, to know how many people have entered the room. If after the first activation in this sense of the sensors appears the same order of activations, it will be considered that another person has entered the room. The light being turned on, the output will not be activated, but will only increase the number of visitors.

– <u>Light off</u>. The principle is the same as in the previous case, but the order in which the sensors will be activated is the reverse. The first must be activated Sensor 2 and then Sensor 1. The counter will be decreased and it will be considered that a person has left the room. When the counter reaches the value 0 it is considered that all the people have left the room and then the light will be turned off, by setting the digital output to 0 Logic. In the Fig. 3 it can be seen that in this case the order in which the sensors are activated is: Sensor 2 and then Sensor 1.

Fig. 4 shows the front panel of the instrument for decreasing the counter and turning the light off.

Fig. 4 – The front panel of the virtual instrument for the case „Light off”.

The sensors can be placed under a carper both in the hallway and in the room, the room being considered septic (medical laboratories for ex.) must have a carpet for disinfection.

Fig. 5 shows the diagram for the acquisition of the analogic signal and its transformation into a digital signal.

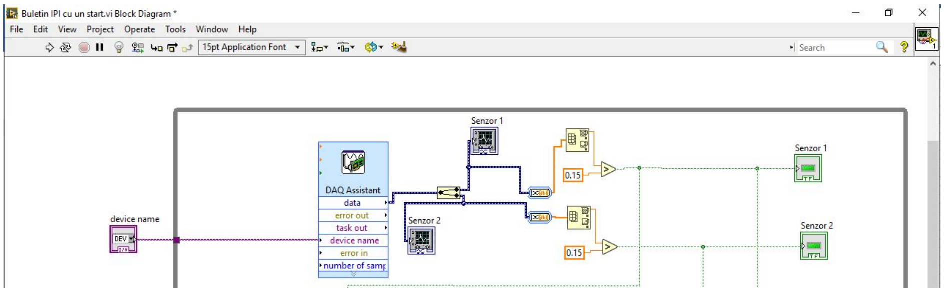

Fig. 5 – The diagram for the acquisition of the analogic signal and its transformation into a digital signal.

If more than one acquisition board is connected, the board to be used will be selected. Then the propper parameters will be selected: the type of input that can be single ended or differential; the measured signal (voltage, current), etc. In Figs. 2 and 3 the board is presented as "Device name". This selection field is connected to the "DAQ Assisent" subVI, which will be configured as having two analog inputs, AI0 and AI1. The output of this subVI will give the data from two inputs; therefore it is necessary to separate those two signals. Thus, the "Split Signals" block will be used. At the output of this block we will have those two independent signals that will be processed later. Once the signals are obtained, they are graphically represented to see if the processed signals are the correct ones. The data is converted from "Dynamic data" format into 1D Array format and then the maximum signal value will be searched using the "Array Max & Min Function" tool. The maximum extracted from the vector value will be compared to threshold value using a comparator. If the maximum value is greater than the threshold value, then a boolean True signal will be obtained at the output of the comparator. This signal will activate a "Case" structure, which will contain two conditions:

– The "TRUE" case. First of all, the function of digital output activation will be defined as having the value of 1 logic. The "True" case (Fig. 6) is activated when 1 Logic signal appears from the Sensor 1. The tool "DAQmx Start Task (VI)" will be used to initialize and configure the acquisition board. After this stage the tool "DAQmx Write (VI)" will be used. It will write the predefined function on a single line of the digital output port. This virtual instrument will be activated by the AND logic gate, when both sensors are activated and 1 Logic signal appears. A delay of 5 seconds will be added. It is considered to be enough for a person to pass the entrance and activate the second sensor. The counter will also be increased by one unit.

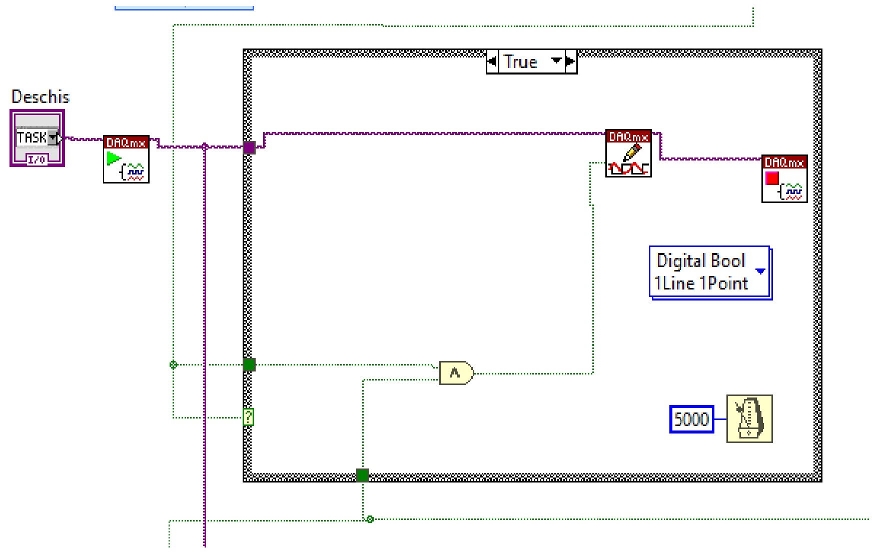

Fig. 6 – "True" case.

– The "FALSE" case, Fig. 7. In this case the signal from Sensor 1 will have the 0 logic value, and the "Case" structure will have the sequence "FALSE". The writing to the digital port instrument will have the 0 logic sequence defined, so the output will remain in 0 logic.

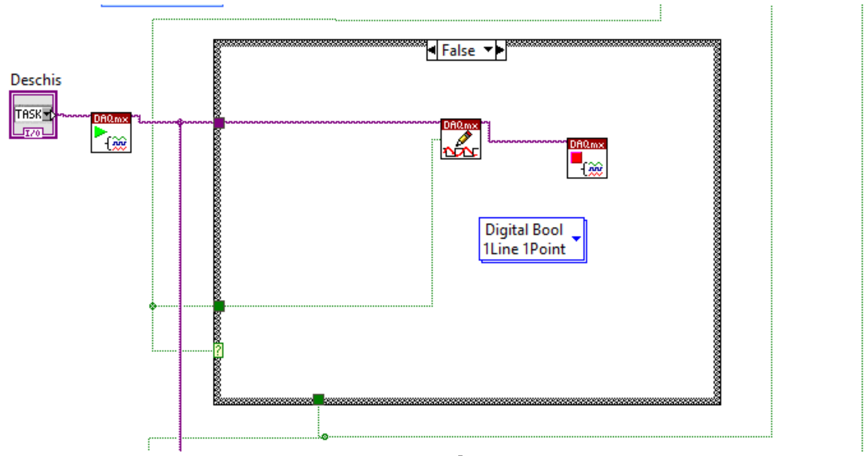

Fig. 7 – "False" case.

The same instruments will be used to turn off the light. The difference is to wait for the signal in reverse order: first from Sensor 2 and then from Sensor 1. The block diagram with all the instruments for both cases is shown in Fig. 8. Once the sensors being activated in this order, the counter will decrease, and when it reaches zero, the light will be switched off. The light cannot be turned off just by simple activation of the sensors in the correct order, without using a counter. This is because the light would be switched off whenever a person comes out of the room even if there are other people in that room.

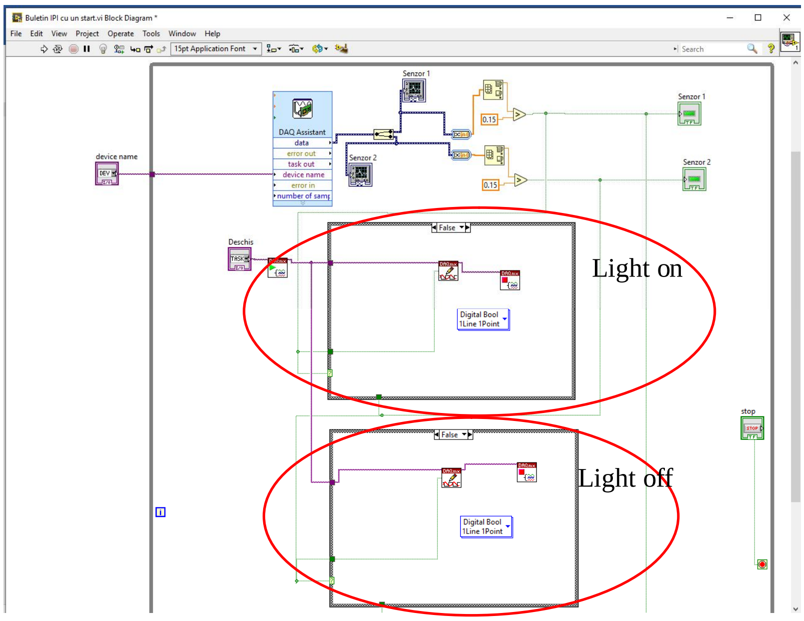

Fig. 8 – The diagram used to turn off the light.

A presence sensor (PIR) can be used in the hallway to activate the lighting of the room. Once the light is on, it will stay on if the piezoelectric sensors are activated in the order Sensor 1 (mounted in the hallway) and then Sensor 2 (which is mounted immediately at the entrance to the room). This pre-lighting before entering the room is useful for adaptation of the eye when passing from a lighted area (hallway) to a dark area (room). If passing through the PIR sensor in the room the light is already on, it stays on and the number of people from room will be only increased by one. When the sensors are activated in the opposite direction (Sensor 2 and then Sensor 1), the counter will be decreased by one. When the counter reaches the value zero the light in that room will be switched off.

3. Conclusions

This application is very useful in the aseptic area, where there should be as few as possible chances to bring microbes or dangerous bacteria by the working staff by touching anything in that area. Thus, using of this non-contact light on/off system can greatly reduce the transmission of microbes or bacteria from one human to another. The proposed system and algorithm are not necessarily designed for high-risk hospitals, where extreme measures are needed. The authors proposed a simple algorithm for turning on the light that does not require the manipulation of other devices, such as the remote control, the smartphone, etc. This system also requires just a few adjacent elements for operation. This type of automatic lighting is useful when the person has its hands busy with medical instruments or dirty, to avoid touching of the classic switch.

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REFERENCES

Alzubaidi S., Soori P. K., *Energy Efficient Lighting System Design for Hospitals Diagnostic and Treatment Room – A Case Study*, April 2012, Journal of Light & Visual Environment, **36**, *1*, 23-31 (2012), DOI: 10.2150/jlve.36.23.

Bhuvana S., Prathiksha H., Sindhu V.T., Vasudha H., *Design and Analysis of Piezoelectric Cantilever Based Vibration Sensor*, IEEE International Conference on System, Computation, Automation and Networking (ICSCA), Pondicherry, India, 2018, DOI: 10.1109/ICSCAN.2018.8541161.

Dalke H., Little J., Niemann E., Camgoz N., Steadman G, Hill S., Stott L., *Colour and Lighting in Hospital Design*, Optics and Laser Technology, **38**, *4-6*, 343-365 (2006).

Ganeshkumar D., Manigandan T., Palaniswami S., *Virtual Instrumentation Based Intelligent Vibrobench for Bearing Testing*, International Conference on Industrial and Information Systems, Penadeniya, Sri Lanka, 2007, DOI: 10.1109/ICIINFS.2007.4579224.

Hua C., Chen Y., Zhao S., *Investigation of the Measure and Control Method for Vibration of the Variable-Frequency Precisely Cropping Machine*, First International Workshop on Education Technology and Computer Science, Wuhan, Hubei, China, 2009, DOI: 10.1109/ETCS.2009.326.

Rizzo P., Rea M., White R., *Lighting for Today's Neonatal Intensive Care Unit*, Newborn and Infant Nursing Reviews, **10**, *2*, 107-113 (2010), DOI: 10.1053/j.nainr.2010.03.007, Corpus ID: 72769757.

Shah H. S., Patel P. N., Shah S. P., Thakker M. T., *8 Channel Vibration Monitoring and Analyzing System Using LabVIEW*, (transl. from German), Nirma University International Conference on Engineering (NUiCONE), Ahmedabad, India, 2013, DOI: 10.1109/NUiCONE.2013.6780181.

* * * National Instruments, *Getting Started with LabVIEW*, Worldwide Technical Support and Product Information, June 2013, 373427J-01.

SISTEME DE TESTARE SENZORIALE CAPACITIVE C ŞI RC PENTRU CONTROLUL AUTOMAT AL ILUMINATULUI

(Rezumat)

În acest articol autorii propun un sistem automat de aprindere a luminii folosind senzori piezoelectrici. Este propus un algoritm software pentru identificarea sensului de deplasare (intrare sau ieşire din laborator) a unei persoane. Acest algoritm identifică ordinea în care sunt acționați cei doi senzori piezoelectrici. Sistemul propus pentru automatizarea controlului luminii are două funcții: reducerea consumului de energie într-un spital şi de evitare a atingerii de către mai multe persoane a unor suprafețe posibil infectate sau murdare.