

# EXPERIMENTAL TESTS IN NON-DESTRUCTIVE LABORATORY

## *On-line Experiment: Monitoring Sensors*

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Abstract: In this paper the construction of hypertext which simulates a virtual laboratory (Non-Destructive Laboratory) will be described. The hypertext was applied to on-line experiments associated to the study of industrial automation processes, e.g., the monitoring of temperature, pressure and flow sensors. A test platform and an HMI (Human Machine Interface), developed in the software LabVIEW, were used. The HMI is published in the Web Server while the experiment is being executed. Thus, the students can assume a hybrid role in the learning process, not only acquiring new knowledge in the study area, but also producing it by means of this hypertext.

## 1 INTRODUCTION

The new technologies of information and communication are changing the process of learning and research. The computer is the main technological element which enables these changes. Today, the computer is a potentially capable tool to start and diffuse new experiences and ideas in the education (Tinio, 2002).

Another methodological tool that facilitates the learning process is the hypertext (web site), which allows the user to work in an interactive way: exploring, importing and updating the present content in a web page. This interactivity promotes intellectual growth opportunities. Furthermore, the skills and competencies developed help the users solve quotidian problems more easily (Shapiro and Niederhauser, 2002).

Many universities and colleges, throughout the world, that deliver undergraduate programmes in science and engineering are currently incorporating virtual instruments as teaching, measurement and analysis for student learning (Tiernan, 2010). Industrial Automation is one of the large areas in Electrical Engineering in which undergraduate student needs to have knowledge about development

and usage of HMI's control. LabVIEW is a graphical programming environment which implements interfaces based on windowing using interactive icons to issue commands and observe the operation of the measurement systems. This software allows the execution of on-line experiments using HMI's published in the Web Server. Therefore, a student, being anywhere in the world, can track the complete execution of experiment in real-time (Consonni et al, 2004).

The students can view the obtained data in your computer or any electronic equipment connected in the Internet. Simultaneously it can research another subjects related to the experiment and contributing for the knowledge decentralization and enhance the learning experience of undergraduate engineering student using a computer.

In this context, the objective of this work is presents a hypertext which simulates a virtual laboratory for realization of on-line experiments associated the study of industrial automation process, e.g., the monitoring of temperature, pressure and flow sensors. A test platform and an HMI, developed over LabVIEW 2009, were used. The HMI is published in the Web Server while the experiment is being executed.

## 2 MATERIALS AND METHODS

The hypertext was developed using the technology Google Sites, which the HTML code is specified in link: <https://sites.google.com/site/nondestructivelab/>. In the Non-Destructive Laboratory web page, the sidebar was divided in three links:

- **Home-page:** There is a brief summary about the purpose of creating the site.
- **Experiments:** There are the sub-links that allow the student perform the on-line experiments wanted.
- **Comments:** Is a placeholder where the students can share another links or files associated with the subject of the realized experiment.

One of the screens of the site Non-Destructive Laboratory can be observed on the Figure 1.

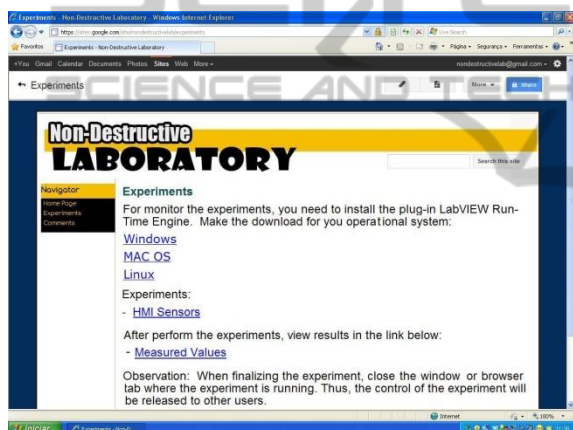


Figure 1: The screen of link “Experiments” of the Non-Destructive Laboratory site.

Before the realization of the on-line experiment, the student needs to have knowledge about the industrial automation system in study. This system, projected and built in the Laboratory of Electronic Instrumentation and Control (LIEC) of the Federal University of Campina Grande, is constituted by the following elements:

- **Test Platform:** Set of galvanized iron tubes interconnected, simulating a fluid transport system. The flow and pressure sensors are fixed in the tubes and the temperature sensor is submerged in the fluid stored in the tank (Figure 2, picture a).
- **PLC (Programmable Logic Controller):** Is a device responsible for technology integration between sensors and computer. The PLC chosen for the information

processing of this system was SIMATIC S7-200 Micro PLC from Siemens (Figure 2, picture b). This Micro PLC is a reliable, fast and flexible controller for basic automation tasks. The PLC is constituted of a CPU 226 and a set of optional expansion modules such as AD converter module EM235 – 4 analog inputs and 1 digital output. In addition, there is a PC/PPI cable that allows establishing the communication between RS-232 serial port of the computer with the S7-200 CPU (Siemens, 2000).

- **Computer:** Device in which the PLC programming will be realized by the STEP7 Micro WIN software and the monitoring of sensors using the HMI via LabVIEW (Figure 2, picture c).



Figure 2: Industrial automation system in study. Picture a: Experimental Test Platform; Picture b: S7-200 Siemens PLC; Picture c: Computer with LabView.

As the main idea of the on-line experiment is the monitoring of sensors. The main characteristics of sensors are explained for a better understanding about the interface exhibited in the hypertext. The sensors used were:

- The LM35 temperature sensor (Figure 3a) is a precision sensor which has a low output impedance and voltage linearly with the temperature measured at the time (10mV equals 1°C) (National Semiconductor, 2000).
- The turbine flowmeter (Figure 3b), which the frequency of pulses, generated due to rotation of the propeller installed in the direction of flow, is possible to measure the speed the fluid. The sensor has a flow

transmitter to measure and a display panel that supplies exact lectures in flow scale 3 to 38 LPM (FlowMeters.com LLC, 2003), (Georg Fischer Signet LLC, 2011).

- The pressure sensor type Strain Gauge (Figure 3c), based on the principle of wire resistance change. It has the pressure variation proportional to the elastic deformation, traction or compression, subjected to the wire. The sensor offers digital display in 9 pressure units: psi, mmHg, Pol Hg, ft H<sub>2</sub>O, MPa, KPa, kgf/cm<sup>2</sup> e Bar (Ashcroft, 2006), (Wilson, 2003).

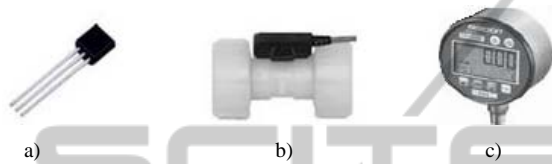


Figure 3: a) LM35 temperature sensor; b) Flow sensor (Signet, model: 8550-1); c) Pressure sensor (Ashcroft, model: 2274 XAO).

To execute the experiment, the student accesses the Internet at the time scheduled with the teacher and logs into his account in the Non-Destructive Laboratory site. At LIEC, the experimental test platform is turned on and the HMI developed in LabVIEW 2009 is opened in the matrix computer by the teacher.

During the execution of the experiment, the student clicks at the link “HMI Sensors” present in “Experiments” to display the HMI in the Web Server. If the student does not have this graphical software or this version used, it is necessary to install the plug-in LabVIEW Run-Time Engine in his computer in accordance with the operational system used. The plug-in download can be done in the “Experiments” page.

When the monitoring is finished, the student closes the browser tab, so that the control of the page will be released another student, and views the measurements at the link “Measured Values”. If he wants to share another links, files or doubts associated to the subject of the realized experiment, the student writes in the dialog box present at the link “Comments”.

### 3 RESULTS AND DISCUSSIONS

The hypertext “Non-Destructive Laboratory” is still in development phase. This page will be inserting in the discipline of Electronic Instrumentation

Laboratory in the undergraduate degree in Electrical Engineering from Federal University of Campina Grande as e-learning. So that, the students learning through contents is posed in the computer or Internet and the teacher, use the Internet as means of orientation, with intermediate classroom sessions.

The HMI presented in the site as shown in Figure 4 contains four frames: the frame at left hand side refers to serial port configuration and the three frames at the right hand side refer to the monitoring of sensors, each one featuring a numeric indicator associate the respective graphic.

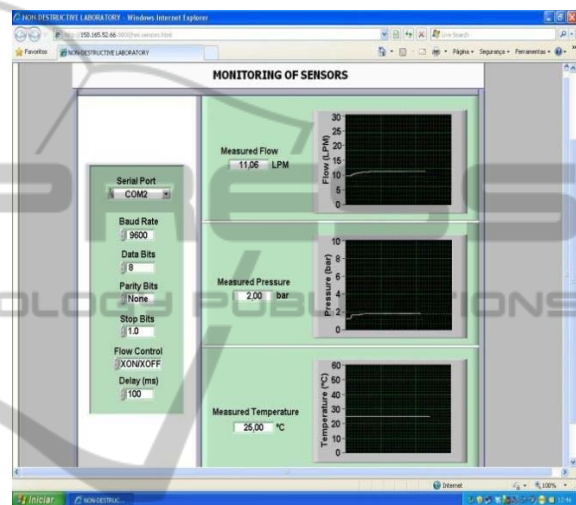


Figure 4: The screen of the HMI developed at the link “HMI Sensors”.

In addition, while the interface is running, it is generated an  $n \times 3$  matrix, where the rows are the  $n$  samples obtained and the 3 columns are the flow, pressure and temperature measured, respectively. The measurements, viewed at the link “Measured Values”, can be used by students to make a further analysis about experiment realized as shown in Figure 5.

There are many advantages of deploying a remote engineering laboratory in an educational environment. Such a strategy provides a way to provide more hands-on time for engineering students in an efficient, flexible and cost effective manner. In other words, since equipment can be used more efficiently with a remote access strategy, fewer instruments are required to serve the same number of students. This is especially true for electrical engineering departments that may have limited access to laboratories and higher cost test equipment in particular (Popescu and Odbert, 2011).

Flow (LPM)	Pressure (bar)	Temperature (°C)
10,547500	1.419281	25,514340
10,550391	1.418719	25,514340
10,550391	1.419158	25,520851
10,551836	1.419375	25,516510
10,551836	1.421344	25,516510
10,551836	1.428187	25,518681
10,583633	1.616437	25,514340
10,615830	1.630969	25,518681
10,654453	1.640344	25,518681
10,684805	1.641094	25,518681
10,716602	1.645219	25,518681
10,749844	1.653000	25,520851
10,777305	1.655437	25,518681
10,806211	1.664719	25,525191
10,836562	1.671938	25,520851
10,864023	1.676531	25,018681
10,897266	1.678500	25,018681
10,923281	1.681194	25,018681
10,947852	1.683000	25,018681
10,973867	1.687031	25,010851
10,996992	1.702187	25,010851
11,017227	1.799023	25,010851
11,037461	1.895859	25,004340
11,057695	2,008594	25,004340

Figure 5: The screen of the link “Measured Values”.

## 4 CONCLUSIONS

In this paper are presented the advisability of using technology tools for auxiliary the process of distance learning, for example, a hypertext which simulates (emulates) a virtual laboratory for realization of on-line experiments. In this case, the use of HMI's connected with Web Server is a way to bring electrical engineering students to the reality of the labor market in industrial automation: explore the phenomena in study, visualize expected outcomes and search possible solutions.

Also, the flexibility of iteration between students and teacher provided by technology tools establishes a new dynamic of teaching. The students can better organize your questions and subjects under study and they have the initiative to find their answers.

The innovative use of technology applied to education, and more specifically, the distance education, must be supported by a philosophy of learning which provides the students the opportunity to interact, to develop joint projects, to recognize and respect different cultures and to build knowledge.

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