ACCESS AND REMOTE CONTROL OF A THERMAL SYSTEM USING LABVIEW AND MOODLE

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ABSTRACT

Training module M2CI is a system that allows both undergraduate students and professionals to acquire control engineering skills and competencies related to the automation of processes. The M2CI has several sensors and actuators for interacting with temperature, position and liquid level plants. Currently the National Open and Distance University has three training modules M2CI located in Bogotá, Bucaramanga and Neiva cities. Engineering students who wish to practice with this system should be addressed to any of these three cities. However, many times the students do not have the means to travel to these cities or do not have time to use these equipment on the schedules in which the UNAD attends the individuals, causing an underutilization of the M2CI.To solve this situation, an application that allows access to the M2CI remotely was implemented. Specifically, access to the temperature plant via the internet is provided, in order to apply classical control techniques such as PID. In this way a virtual learning space was created using LabVIEW to design the user interface that allows remote monitoring and MATLAB to perform signal processing and information processing. In addition, MOODLE was used as a general access tool to the temperature plant and to establish the laboratory schedule. The most relevant scope of the project was the development of an important tool for access to laboratory practices for students of the Electronic Engineering program, fundamental for the training of professionals.

Keywords: Lab VIEW, mobile device, remote access, virtual instrumentation.

1. INTRODUCTION

One of the most significant and accelerated advances of the last 20 years has been telecommunications and computer networks, which has been a consequence of the rapid development of computer systems. The education sector has not been isolated from this new paradigm of information and communication networks, so that there are already virtual learning environments as there are in the National Open and Distance University (UNAD, for its acronym in Spanish), which offers to the students the possibility of taking their subjects through virtual mediation, using a MOODLE platform, on which are mounted the academic courses necessary for their professional training.

In this context, when there is a pedagogical structure mounted on the telecommunications networks, it is not possible to overlook the laboratories that support the practical component of some courses. For this reason, the main objective of the project was to provide remote access to physical laboratories to support and contribute to the development of scientific knowledge, regardless of the distance or time that might hamper this process. Currently there are many universities and companies in the productive and health sectors that use remote access through telecommunications networks to overcome the space-time constraints that their systems impose to monitor or control, and there are many variants that have been used to achieve this objective; from access through a Local Area Network (LAN) to the use of the Internet in global coverage monitoring and control systems.

2. MATERIALS AND METHODS

Currently, UNAD has three M2CI modules for the development of laboratory practices, which are located in the cities of Bogotá, Bucaramanga and Neiva. However, many students are unable to attend the cities where the laboratories are located for spatial and temporal reasons that characterize the distance education. Spatial, because due to their geographical location it is impossible for them to travel to the educational center where these didactic elements are found; and temporary, because even when living in these cities, the working hours of the students are in conflict with the schedules destined to carry out these university practices. This problem constitutes a factor of underutilization of resources and there is no possibility of the appropriation of knowledge through the implementation of this in a real and controlled environment, because although the university has the laboratory, it is not used by the whole of the students.

Access and remote control of the temperature plant included in the M2CI would be a useful complement to the development of laboratory practices of students located anywhere in the country and the world. In addition, it would enable the use of this learning tool in a more open and flexible schedule that adapts to the temporary needs of some students with limitations in the access to laboratory resources. With this, the UNAD would be fulfilling its mission and its modality in the area of the laboratories to contribute to the use of these training scenarios, obtaining an appropriation of the knowledge and therefore quality training.

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3. RESULTS AND DISCUSSIONS

3.1 Identification of the thermal system

The main component of the thermal system is the furnace, which has two resistors connected in parallel each from 720 W to 120 VAC. The oven has a thermostat for temperature regulation. Another component of the system is the power conditioner, consisting of a Solid State Relay (SSR) which receives a PWM signal from 0 to 5 VDC and converts it to a voltage from 0 to 120 VAC which feeds the kiln.

The method used to find the model of the thermal system is that of the reaction curve. To obtain this curve a data transfer interface with LabVIEW was designed. This shows the response of the plant to a step input signal (Figure-1).

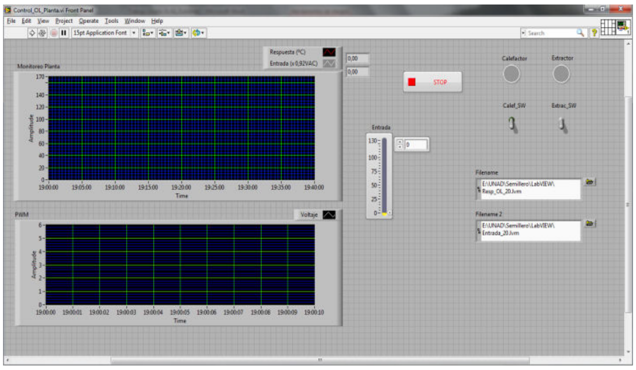

Figure-1. LabVIEW data acquisition interface.

Response data was exported to MATLAB for better visualization and analysis. In Figure-2 it can be seen that the shape of the wave resembles a letter"s" and also that its slope is not so pronounced, so that the thermal system can be represented with a second order transfer function. There is also a small dead-time to be taken into account in the transfer function.

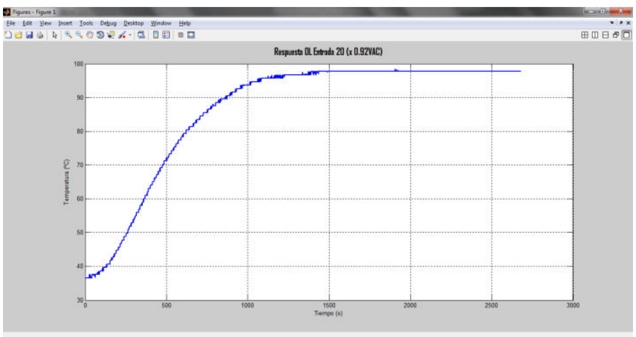

Figure-2. Response of the thermal system to a step input.

Using the IDENT tool included in MATLAB, the real data of input and output of the system were entered, two poles and a delay time were assigned to the transfer function. IDENT performs model validation and delivers a percentage of fit between model response and real response for greater identification certainty. The model obtained with IDENT appears below and its adjustment percentage is 95.77%.

$$G_P(s) = \frac{3.007e^{-38.41s}}{54809.34s^2 + 470.19s + 1}$$

3.2 PID Controller design

Open-loop systems do not provide adequate control because they need to be adjusted repeatedly to achieve the desired response. To overcome this problem, the control loop must be closed and then a controller must be designed to obtain the desired response under defined conditions.

With the response of the open loop model obtained in the previous section, the PID controller is designed using the Ziegler-Nichols reaction curve method [1], which is shown in Figure-3, and whose parameters (P, I and D) are observed in Table-1.

$$k_0 = \frac{y_\infty - y_0}{u_\infty - u_0}, \quad \tau_0 = t_1 - t_0, \quad \gamma_0 = t_2 - t_1.$$

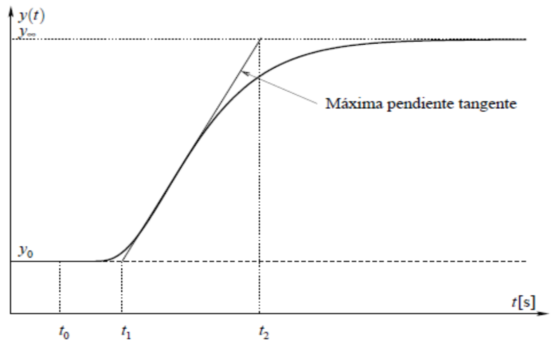

Figure-3. Design method using the Ziegler-Nichols reaction curve.

Table-1. Parameters P, I and D.

	K_P	T_r	T_d
P	$\frac{\gamma_0}{K_0\tau_0}$		
PI	$\frac{0,9\gamma_0}{K_0\tau_0}$	$3\tau_0$	
PID	$\frac{1,2\gamma_0}{K_0\tau_0}$	$2\tau_0$	$0,5\tau_0$

With this design method the following parameters were obtained: $K_P = 2.496$, $T_i = 108$ seconds and $T_d = 27$ seconds. The controller equation appears below:

$$G_C(s) = 2.496\left(1 + \frac{1}{108s} + 27s\right)$$

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A LabVIEW routine was then designed to simulate that controller. The plant response for a reference of 100°C is shown in Figure-4.

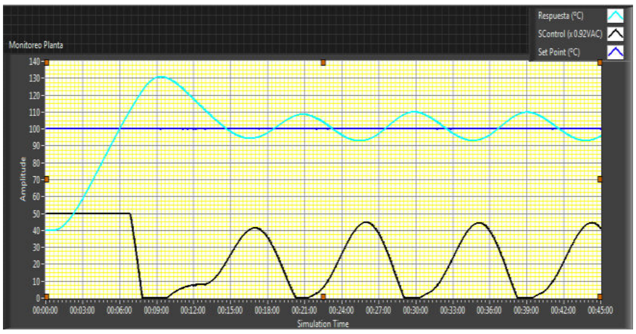

Figure-4. Controlled system response with $K_P = 2.496$, $T_i = 108$ seconds and $T_d = 27$ seconds.

Checking the response of the controlled system it is observed that there is an overshoot of 50% and a rise time of 240 seconds, because the controller still needs fine tuning. Basic control actions, such as the integral and the derivative, should be taken into account; the first one can give instability but it eliminates the error in steady state, the second one serves to stabilize the system and therefore also reduces the overshoot because this action anticipates the error [2]. It should also be noted that according to the configuration of the PID control being used, a change in the value of K_P leads to a change in the integral action ($K_i = K_P/T_i$) and in the derivative action ($K_d = K_P T_d$). Taking this into account, a fine adjustment was made and the response presented in Figure-5 was obtained with$K_P = 0.6$, $T_i = 432$ seconds and $T_d = 27$ seconds.

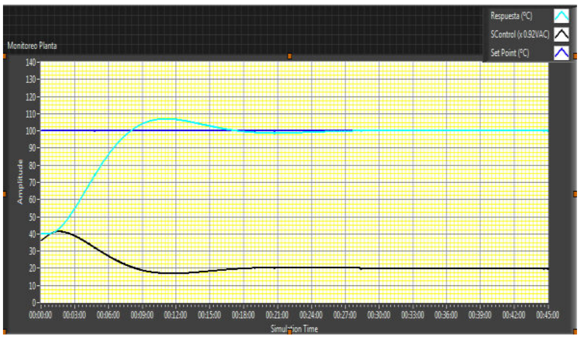

Figure-5. Controlled system response with $K_P = 0.6$, $T_i = 432$ seconds and $T_d = 27$ seconds.

3.3 Implementing the PID Controller

An interface was created in LabVIEW to implement the PID controller designed in the previous section (see Figure-6). On the front panel there are controls where the user can select the desired setpoint and adjust the parameters of the PID controller. In addition, the response of the plant, the control signal applied and the chosen setpoint can be saved. There are also switches to turn on/off the oven heater, to turn on/off the extractor and push buttons to start and stop program execution. There are two graphs, the one above is used to monitor the plant and the one below shows the PWM signal applied to the SSR that feeds the furnace. Instructions for use have also been included in the lower right corner.

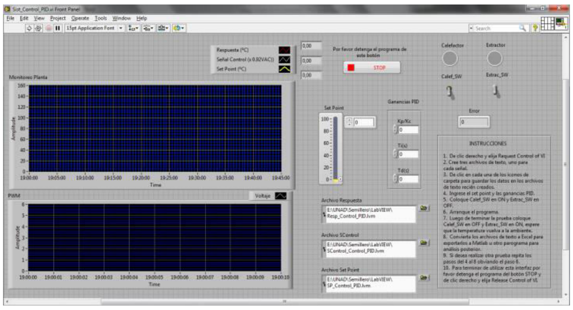

Figure-6. PID control system.

3.4 Remote access

In order to access the thermal system remotely, the MOODLE platform was used, which is a technological platform LMS (Learning Management System), being a web application with a course management system [3]. This platform is of free license and is also used by UNAD for the development of the virtual courses offered to its students. MOODLE is an application that requires to be installed on a web server, for access through a LAN or through the Internet. For this work we used the MOODLE installation type on the Internet. In addition, the remote laboratory module for MOODLE, developed by Sáenz and Gacharná [4], was installed.

The users can connect to the virtual classroom of MOODLE through any device: laptop, desktop, mobile device, etc. There, users can perform their practices with remote manipulation of the temperature plant, having availability 24 hours of the day to enter to their activities by scheduling and requesting the date, time and duration. Access to the temperature control interface (Figure-7) is made possible by the Web Publishing tool and the virtual instrument G Web Server Control. The first one is responsible for publishing the interface at a local level, while the virtual instrument converts the computer, where the web page is created, in a server that can be accessed from the Internet through port 8000 using a public IP address.

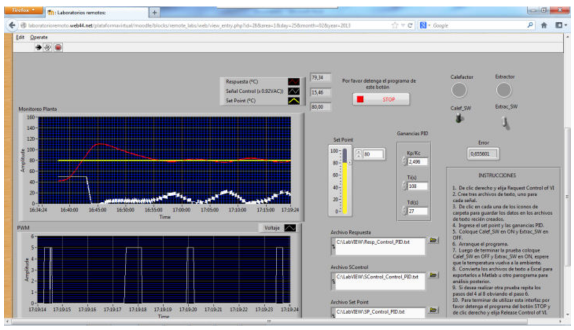

Figure-7. Access and remote control.

4. CONCLUSIONS

The use of the IDENT tool of MATLAB allowed obtaining a mathematical model that represents very well the dynamics of the thermal system.

The PID controller design using the Ziegler-Nichols reaction curve method allows finding the initial parameters for the controller. However, it is necessary to tune these parameters in order to obtain a stable closed loop response, with little overshoot and low settling time.
The tool created in this work allows students to test their knowledge of PID controllers and to develop the skills and experience to be able to use this type of control in a real environment.

Remote access to the thermal system allows real-time monitoring of what happens to the temperature plant at all times. At the same time it allows to modify the set point and thus to observe how the designed controller responds to these changes in the reference temperature.

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