Online PID Control of Tank Level System

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Abstract—In this work we present the remote control of the tank level system. The physical system is controlled in real time using local or Internet network. The client could manage the remote experiment through a simple web browser via a graphical shared user interface. The study is based on the PID identification parameters according to Ziègler-Nichols methods. After the identification of the PID parameters the experiment is tested and the result are given.

Keywords— tank level control, interactive remote laboratories; PID controller; online learning.

I. INTRODUCTION

Experiments lab occupies a very important place in the learning methodologies. In the engineering fields, the students pass a large part of their time in these labs. However, the achievement of the practical experiments requires in the most cases expensive equipment such as: measuring instruments, acquisition cards, computing stations, …etc. on the other hand, the considerable increase of the student number needs the duplication of experiment work stations. This contributed also to increase the experiments global cost. In this case the majority of educational institutions suffer in front of this logistical problem. Therefor, the remote labs give a practical solution to this problem. They allow sharing the same experiment lab to a larger number of students. Moreover, they give a remote access to hardware experiments without the necessity of people displacement. So, they lead to save the time and reduce inactivity days.

Remote labs capitalize the large diffusion of the Internet over the world. Essentially, they exploit web-based platforms to give an interactive interface to the users. This interface interacts directly with the remote hardware via requests-answers sent on the network. Many architectures and platforms are used to achieve these objectives. From the user's side, only a simple web browser (Internet Explorer, Mozila Firefox) with generally an appropriate plug-in is necessary (JRE for applets based interfaces, runtime engine for a LabVIEW based remote experiments).

In electrical engineering fields, many online laboratories have been developed [1-4]. Some of them deal with fundamental electronics and process control experiments. The aim of this paper is to present the design details and test process of an online tank level control system. Beyond its classical aspect, this choice is motivated by the fact that the physical system is simple but relevant. Both identification and online PID controller design are included in the remote experiment.

This paper is organized as follow: the hardware and the software part are reported in section II. In section III, the objectives, technical content and procedure of the remote experiment are presented. This is done either from the experiment designers or administrators side or from the remote-student side. The remote experiment test is presented in section IV. Finally, conclusions and some perspectives are given.

II. EXPERIMENT DESCRIPTION

The work described in this paper was performed within the framework of the Tempus e-science project (Euro-maghribeen project financed by the European community) where the University of Frères Mentouri Constantine is a partner. The main objective of this project is the use of new technologies in order to develop e-learning in the electrical engineering field, especially the implementation of remote labs, for experimental works.

A. Hardware Part

In this part, the design of an interactive network structure is described. This structure allows students to supervise and control the tank level in an experimental system using a PID controller. This architecture gives the students the opportunity to change the desired level value and the PID controller parameters during the experiment from any terminal connected to the Intranet or Internet network. Different kinds of network architectures can be used for an ilab [5]. The network architecture of Constantine iLab is represented in Fig. 1 and the system used for the tank level experiment is shown in Fig. 2.

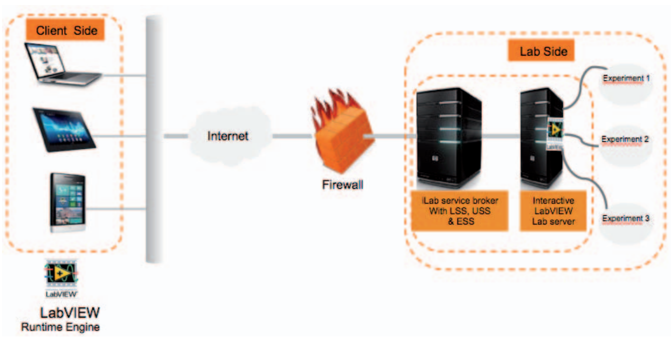

Fig 1. Online lab architecture

It is composed of a level sensor, an acquisition card, lab server and web server. All these parts are connected together according to Fig. 3. This figure shows a closed loop control system. The measured tank level is compared with a reference value. The difference between these two values is processed by a PID controller, which will initiate actions to drive the difference signal toward zero. The supervision and the control of the system output are performed through a graphical user interface (GUI) developed in the Lab server.

B. *Software Part*

As indicated in the above section, the acquisition card used in this work is a NI-6008 card, which is compatible with the LabVIEW development environment [6]. Therefore, this environment is used for data-acquisition, remote monitoring, and control of different experiment parameters via a GUI.

We notice that, the LabVIEW environment can control experiments connected to the Intranet or the Internet network in real time using LabVIEW webserver. It also offers the possibility to control experiments remotely from a web browser. In this case, the only required software for the remote clients is LabVIEW Runtime Engine (can be downloaded freely from National Instruments website).

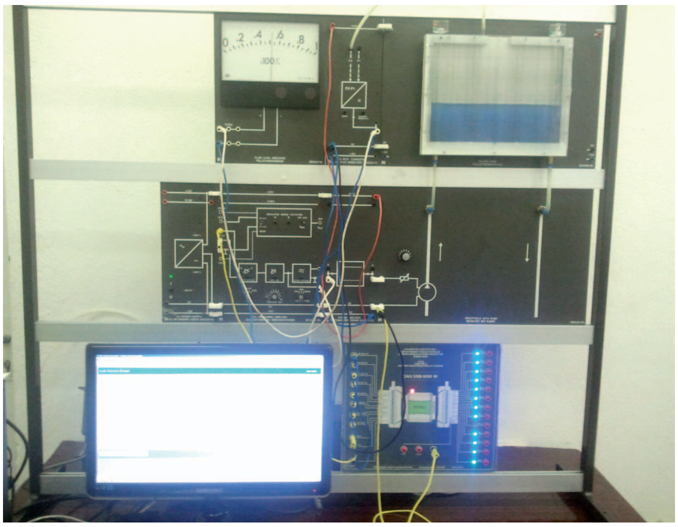

Fig 2. Tank level system

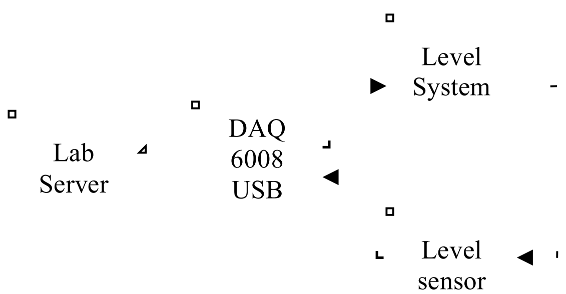

Fig 3.Experiment block diagram

The remote labs experiment exhibited in this paper is based on Interactive Shared Architecture (ISA) developed by V. Judson et al [5]. The fig. 4 represents the interactive shared architecture. This platform allows the client to access through his account in order to: make reservation, launch the experiment, view experiment storage results. The home page of our platform is represented in fig. 5. It is available on http://ilab.umc.edu.dz/ilabservicebroker

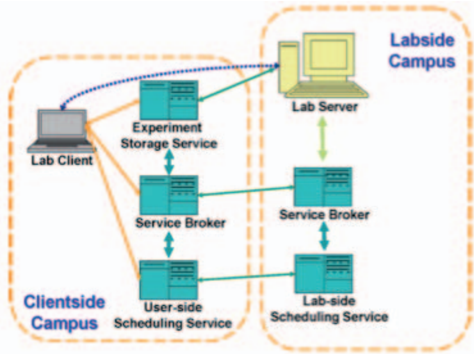

Fig 4.iLab Shared Architecture (ISA)

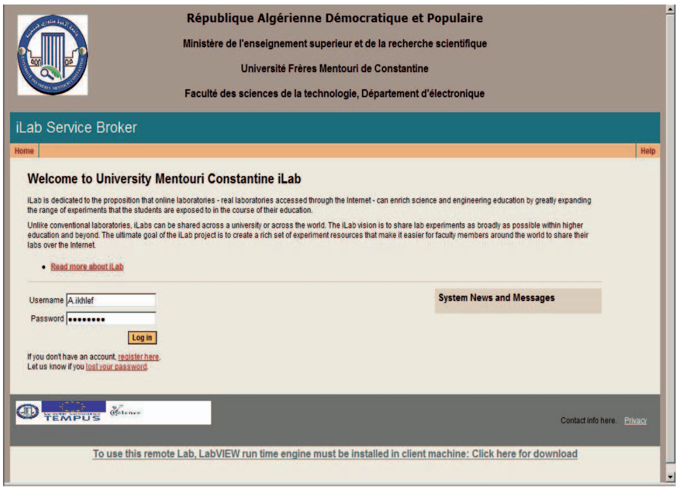

Fig 5. University Frères Mentouri Constantine iLab

As exhibited in Fig. 1, this environment has a lab server that manages the experiment and a web server that handles client access. Real time remote monitoring and control is effectuated by using the LabVIEW webserver. In this case, the developed VI (Virtual instrument) is accessible on the local or the Internet network via web browsers. The remote user regains the control of the experiment only after requesting and receiving acceptance from the server. As described previously, this interactive experiment give the students the ability to run and stop the experiment whenever they want. They can change at any time, the set point level value and the PID controller parameters. Moreover, it is also possible to store all the experiment results data.

III. TANK LEVEL CONTROL REMOTE EXPERIMENT

The level control system is involved in many everyday life systems such as chemical reactors and many other industrial systems [7]. The proposed remote experiment concerns tank level control.

A. Remote Experiment Objectives

The aim of the experiment can be summarized in three objectives which constitute the student work steps:

- Tank system identification from experimental data.
- Open-loop Ziegler-Nichols PID tuning and test on the tank system (ZNOL).
- Closed-loop Ziegler-Nichols PID tuning and test on the tank system (ZNCL).

B. Preparing the Practical Work

Before the physical remote experiment, the students are provided with experimental data obtained from a step response of the tank system. The students are asked to plot the system time answer and to confirm its S-shape. The expected curve is shown in fig. 5.

Once the curve obtained and plotted, they should identify the parameters of a first-order delayed system: static gain K, time constant τ and delay τ_d. The transfer function of the model is of the following form [8]:

$$G(s) = \frac{Ke^{-s\tau_d}}{1+\tau s} \quad (1)$$

C. Remote Experiment Content

As the experimental objectives, the experiment content can be divided into two parts: Open-loop and closed-loop PID tuning and test.

1) Open-loopZiegler-Nichols PID tuning and test:

Once the experimental model obtained during the student preparation, a PID controller is directly obtained using Ziegler-Nichols rule for open-loop identified system [8]. The parameters K_p, T_i and T_d are a function of the answer curve slope a and the model delayτ_d.

From the users side, the remote students have an interface to introduce directly the PID parameters and to make a real remote test on the physical system via a web browser. This interface allows the students to follow in real time the regulated physical system response on the web browser. The student has to do an analysis work to adjust the true parameters if a wrong result is obtained as saturation or overshoot.

For both open and closed loop case, the implemented controller on the measurement server using LabVIEW has the following transfer function

$$C(s) = K_p\left(1 + \frac{1}{T_i s} + T_d s\right) \quad (2)$$

2) Closed losed-loop Ziegler-Nichols PID tuning and test:

For the closed loop case, the process to be controlled is put in a closed loop with a variable gain K0. As shown in Fig 6, the gain is tuned until the system starts to oscillate. The value of K0 causing the start of oscillation and the oscillations period T0 are then used to tune the three PID parameters [8].

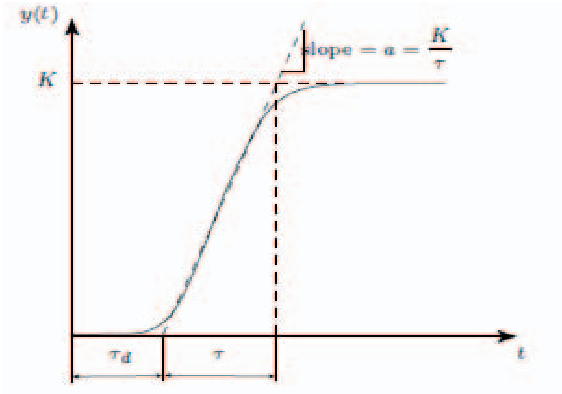

Fig. 5.Open-loop answer of a delayed first order system

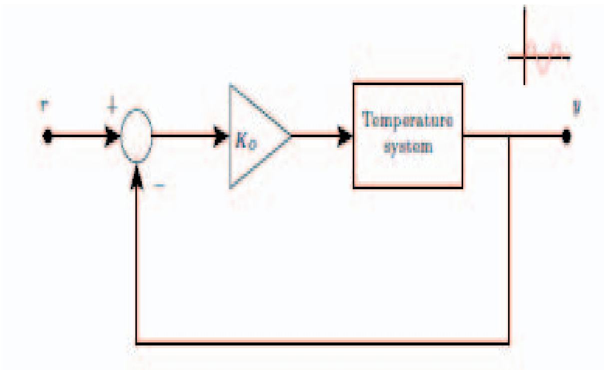

Fig. 6. Oscillating closed-loop response with proportional action.

IV. EXPERIMENT RESULTS

In order to illustrate the performance of the experimental lab described in this paper, the effect results of different PID parameters on the system response have been investigated.

Fig. 7 and Fig.8 represent the obtained results for both identification methods. These curves are acquired from the graphical user interface represented by Fig. 9. They allow the students to identify the parameters of the used PID controller. As an example, the system response for the PID parameters calculated by ZNOL method is reported in Fig. 9.

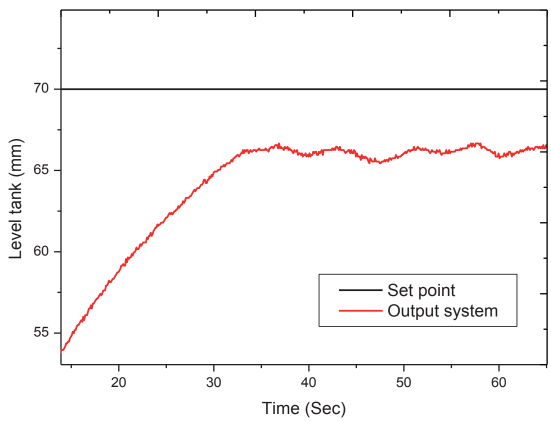

Fig. 7. Oscillating closed-loop response with proportional action.

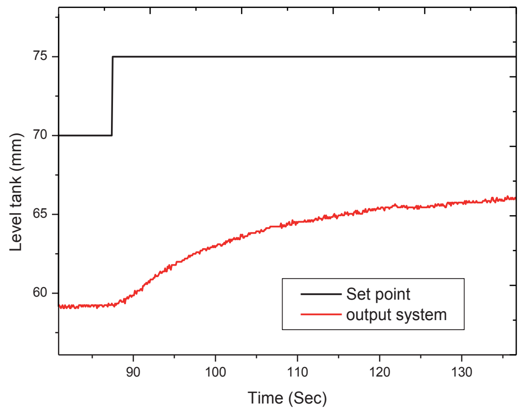

Fig. 8. Step response of the open loop system.

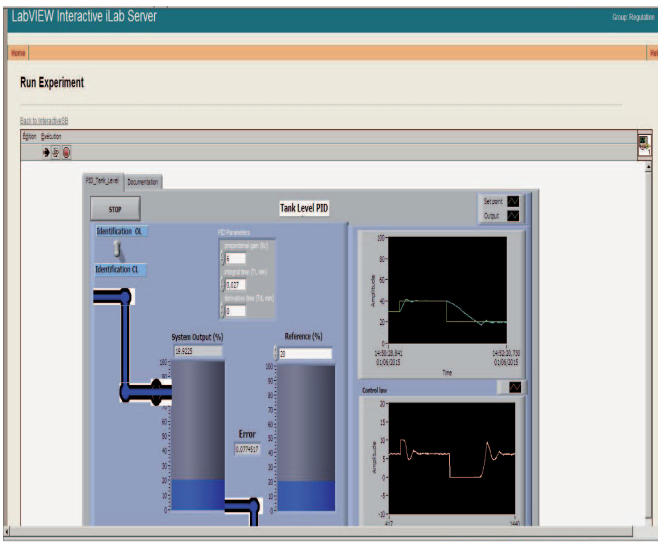

Fig. 9.Graphical user interface as displayed on remote client web browser.

V. CONCLUSION

For educational purpose experiment remote lab is proposed. The tank level system is taken as an example. The experiment can be acceded remotely through a simple web browser. The architecture ISA is used to manage the access of the clients to the physical experiment. Experimental Ziegler-Nichols tuning rules for a PID controller are tested in real time. The control system has been successfully tested on intranet and Internet network and the results are satisfactory.

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