Microelectronics and Intelligent Instrumentation Master: development of a remote laboratory for distance learning

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ABSTRACT

Remote laboratories are a rapidly growing innovation trend in engineering education, as they provide a chance to extend scheduled laboratory sessions to distance-learning students while also represent a learning platform to complement regular courses. The mass proliferation of the Internet, together with the ever-increasing user-friendly computer-controlled instrumentation, have favored the development of such remote laboratories with interactive experiments. This paper presents the implementation of a functional, low-cost and simple remote laboratory system, utilizing computer-controlled instrumentation and the Internet, and the results obtained from its utilization in a Master on Microelectronics and Intelligent Instrumentation.

1. INTRODUCTION

The nowadays layout of the European University offers to the students the possibility of completing their curricula by taking courses proposed not only from the own educational center, but also from other centers belonging to the same University and even to a different one. In this background, it is imperative the development of courses that can be attended remotely, eliminating the major obstacle of the physical presence of all the students in a concrete educational centre at a concrete time.

In engineering education, laboratory courses are a vital part, but so far, lab courses have been considered impractical for distance-education. This paper presents the development and implementation of a functional remote laboratory system, utilizing computer-controlled instrumentation and the Internet, which consists of a complete measurement setup dedicated to circuit characterization. The present version of the remote lab constitutes the lab module in a course on Intelligent Instrumentation at the Microelectronics and Intelligent Instrumentation Master at the University of Zaragoza, Spain. However, based on this concept, lab courses and course modules within many disciplines of engineering and science can be offered to remote students.

2. REMOTE LAB

The remote lab contemplates the following elements:

- Lab set up (Fig.1). It includes a host PC with IEEE 488.2 communication bus and fixed IP Internet connection. Communication between the PC and the lab instruments (a Tektronix TDS210 oscilloscope and a Sony-Tektronix AFG320 signal generator) is performed through a low cost GPIB/ISA card.
- Visualization system. A web-cam connected to the PC enables to verify the correct operation of the lab equipment as a function of the control commands. In this way, through a simple and free web server the student can remotely check the experiment, as shown in Fig. 2.
- Remote lab technical implementation. The possibility to control in a remote way the lab equipment is done thanks to a free Agilent application called Agilent IO Control (Fig. 3) [1]. This application, installed as server in the host PC, allows sharing its instrumentation resources (GPIB, serial and USB ports, with the connected instruments) through the web with any computer using this same application configured as client. The use of this application relaxes the requirements of the server, which is merely a bypass between the instrumentation and the client, thus allowing the use of regular PCs as servers.
- Virtual measurements. The control, data acquisition and processing is realized by using Matlab. This programming language choice is determined by its easy and friendly use, the existence of libraries focused on instrumentation control [2] and its high computing power. Matlab also allows the implementation of a user interface by using the Graphical User Interface Development Environment (GUIDE) [3] (see Fig. 4).

Fig. 1: Remote lab set up

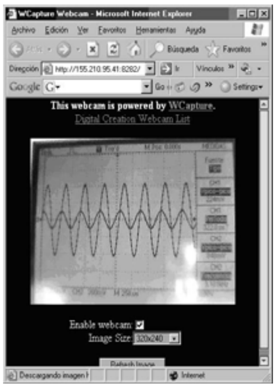

Fig. 2: Webcam image from the oscilloscope screen

3. EDUCATIONAL ASPECTS

The present remote lab version fits within a course on Intelligent Instrumentation in a Microelectronics and Intelligent Instrumentation Master. This course is given making use of the Virtual Campus facilities that provide the University of Zaragoza, Spain, for semi-distance and distance learning [4]. In this Virtual Campus, students can find all the documentation required to pursue the subject, complementary information, as well as the material and applications that allow accessing and using the remote lab.

The employment of this remote lab implies, from the teacher side, a proper programming of the student task in order to be able to manage with all the software applications involved. Therefore, the designed learning process comprises several steps to be performed in the following established order:

- Learn the use of Matlab as programming language and mathematical tool.
- Learn the control commands syntax of the SCPI standard (Standard Commands for Programmable Instrumentation [5]), which is the one employed by the majority of the instruments with PC connexion (RS-232, GPIB, USB, Ethernet). In order to go through this point without the knowledge of the Matlab instrumentation control library, students have a very simple application (Fig. 5) which translates the control commands sent to the oscilloscope in SCPI syntax into Matlab compatible instructions. The own program formats properly the instruction, sends it to the oscilloscope and sends back the instrument answer, in case of a request. Combining this application with the image from the webcam it is possible to check if the sent control commands perform the desired operations.
- Learn how to program the instruments, with the SCPI commands, by means of the Matlab instrumentation library. Once the students have sufficient ability dealing with the standard commands, next step is learning to manage with the Matlab instrumentation library. In particular, in this point, students are proposed to connect remotely to the host PC and send to the AFG320 signal generator the commands that enable to modify its waveform parameters. To visualize the signal and carry out the desired measurements, the AFG320 is directly connected to the oscilloscope. From the course documentation available in the Virtual Campus, it can be downloaded a graphical interface (Fig. 4), which allows the control and screen visualization of the TDS210 lab oscilloscope. In addition, the web-cam can modify its position to show a front image of the signal generator. In this way, it is possible verify that the oscilloscope signal coincides with the web cam signal in the generator and at the same time, with the remote programmed signal.
- Elaboration of a complete measurement system including several instruments (signal generators and measurement equipment) in order to characterize the behaviour of a given circuit or device.
- Elaboration of a graphical interface by using the Matlab *GUI Development Environment*.

Once the student has gone through all these points, the signal generator is connected to the input of an unknown circuit, while the two channels of the oscilloscope are connected, respectively, to the circuit input and output. The student has then to design and go through all the measurement process in order to obtain the circuit transfer function, characterizing both its amplitude and phase. Finally, students have to develop their own GUI, including a number of choices fixed a priori.

4. Results and Conclusions

The described experience has been completely implemented for first time this year. The students who have selected the use of this remote laboratory to realize the experimental part of the course are mainly working people or students whose timetable was incompatible with the scheduled lab experiments. The experience has been positively evaluated by students, who greatly appreciate the flexibility derived from the choice of organizing themselves according to their own time availability.

5. Acknowledgment

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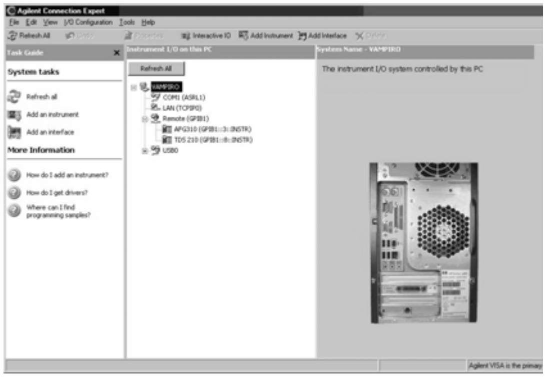

Fig. 3: Agilent I/O control

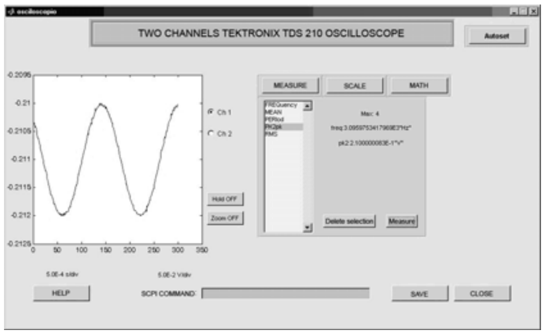

Fig. 4: Virtual Oscilloscope

Fig. 5: Test command application

References

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