VIRTUAL MEASUREMENT SYSTEM
FOR DISTANCE EDUCATION AND TRAINING

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ABSTRACT
This paper deals with the project and the development of remote controlled measurement system designed for distance education and training in instrumentation and measurement. This virtual laboratory system is based on IEEE488.2 (GPIB) and client-server architecture.

KEYWORDS
measurement system, virtual laboratory, distance education, IEEE488.2

INTRODUCTION
The main aim of the virtual measurement system design was the maximal universality. In the case of distant education it means:

• Minimal demands required from the client computer, which serves as a controller of the system
• Multi-control feature (both one measurement system controlled by more client computers and more measurement systems controlled by one client computer)
• Universal and simple communication with remote devices
• Implementation of most the PHP commands for simple programming of measurement tasks (e.g. program loops, conditional statements etc.)

PROJECT
The conditions listed above were fulfilled by the communication protocol based on the client-server architecture. The whole system consists of the following three parts:

• Measurement computer – PC with OS Windows and a GPIB card, which enables the communication with connected measurement instruments
• Client computer – PC with a WWW browser supporting Java, connected to the Internet
• Server computer – PC with OS Linux and WWW server supporting PHP and connected to the Internet; it provides interconnection and communication between two parts above

Fig. 1 Block diagram of the measurement system design
The measuring process is started by the client computer. It sends a user commands to the server computer, which partially preprocesses the requests and redirects them to the addressed measurement computer.

The whole system is controlled through WWW browser. The communication between the client computer and the server computer, as well as between the server computer and the measurement computer, uses TCP/IP protocol. SCPI messages are used for instrument control.

IMPLEMENTATION

Measurement computer

This computer receives commands from the server computer and sends them to the addressed instruments via GPIB bus. It also sends the measured data back to the server computer – it is the data source of the measurement system.

There is a special MS Windows program running on this computer, which provides the communication channel between the measurement instrument (connected to GPIB bus) and the server computer. This program has to be set up at the beginning and then it runs resident on the background. It is mostly waiting for the commands from the server computer or response from a measurement instrument; thus it needs the minimum of the processor time.

Excepting the standard SCPI commands the program can process special commands (e.g. “Delay” or “Trigger”) – see below. The program is also able to recognize an incorrect command and recover from the error state. Thus no assistance is needed and the measurement instruments can be remote controlled without local supervision. If a web-camera is available, it can be connected to the measurement computer.

Concerning the hardware equipment, there has to be installed a GPIB interface card or RS-232 serial line in the measurement computer for the communication of remote devices. Web-cameras usually need an USB interface.

Client computer

As the client computer can serve any computer with any operating system located anywhere in the world (tests were performed on the PC with Microsoft Windows 9x/2000/XP and Linux RedHat 8.0). There are only two conditions – the computer must be connected to the Internet and a WWW browser with Java support has to be installed there.

Concerning the hardware equipment, there has to be installed a GPIB interface card or RS-232 serial line in the measurement computer for the communication of remote devices. Web-cameras usually need an USB interface.

The main window of the virtual measurement system is logically divided into two columns. The snapshot of measurement devices is displayed on the left side of the client page using a web camera (see Fig. 2). The measured task is described below this picture. The visual information is quite important, because it allows the functionality

![Fig. 2 Main window of the virtual measurement system (client program)]
verification of the instrument or the complete measurement system (according to setting of the camera viewpoint). It also proves that users communicate with real devices indeed and not just with a simulation program.

The communication part of the client program is situated on the right part of the window. The simplest way of the communication are SCPI commands addressed to a specific measurement instrument. User has to write a SCPI command into the “SCPI command” field, choose the desired device from the roll-up list and send the message by pushing the “Send” button.

If the command requires a reply from the addressed device (e.g. “READ?”), the response is redirected to the server. In case of an unknown command, the device cannot reply and the error message is sent to the server. The response is displayed in the WWW browser window on the client computer in both cases.

More sophisticated device control is enabled by the implementation of PHP scripting language to the system. PHP language allows using variables, constants, data fields, conditions, cycles etc. in measurement programs (scripts) and translating the output data to the form of web pages using HTML tags. The graphic library JpGraph for PHP (http://www.aditus.nu/jpgraph) makes possible measured data to be displayed in variety of graphs. Measurement scripts in PHP language can be written into “PHP+SCPI script” field. Pushing the “Run” button sends script for execution.

**Server computer**

This computer is a key part of the whole system. It intermediates the bidirectional communication between the measurement and the client computer.

There is a resident C program running on this computer which enables the communication. It works parallel to other system programs (called daemons) running on Internet web server (Apache, MySQL, FTP etc.).

This intermediate program enables measurement computers to connect to the system, to preprocess and send the commands received from the client computer and to store the measured data on the server computer. These data are processed by the PHP script and displayed on the WWW page in the table or graphical form – according to the user request.

Fig. 3 shows the login of the measurement computer to the server computer. First, communication channel ID#9 is assigned to the client computer, then SCPI command “*IDN?” is sent to the measurement computer to the instrument no. 1 (multimeter Agilent 34401A, GPIB address 22) and after that the response of the addressed instrument appears.

![Fig. 3 Server communication program](http://example.com/server.png)

**SYSTEM FEATURES**

**SCPI commands**

The virtual measurement system is controlled by SCPI commands (see IEEE 488.2) through WWW interface. On the WWW client page there is an input field “SCPI command” for a single command.

If the user intends to send more commands or to input a script, there is a special function `GPIB(deviceID:int, command:string)` available for these purposes. The first parameter “deviceID” is the number (identifier) of the measurement instrument and the other one “command” is the SCPI message. The return value of this function is the response of the remote measurement instrument.
**Trigger**

An important function of measurement instruments is the group triggering. This function is implemented by the `Trigger()` command in the virtual measurement system.

**Delay**

In some cases there is an extra time needed for the settling of the measured values especially in the circuits with longer time constants. For these tasks the function `Delay(sec:real)` can be applied.

**Multiuser access**

The measurement system is programmed also with respect to simultaneous work of more users. The control program is equipped by the system of locking access for the case when the device performs instructions sent by another user.

**Outputs**

Measured and preprocessed values are mostly needed in the table form or in the acceptable form convenient for the transmission to another program (e.g. values separated by semicolon for the import to MS Excel). As complete communication with distant measurement system is initiated by an Internet browser through HTML pages, is advantageous to get the output formatted by HTML symbols (called TAGs) in combination with PHP language (very similar to C language). For advanced output it is possible to use functions from the graphic library JpGraph.

**CONCLUSION**

Described virtual measurement system was successfully implemented and applied for distance education and training. For all possible applicants it is available on the Internet address http://sensor.feld.cvut.cz/vl.

For some practical magnetic measurements there has arose a special request on the virtual system. In contrast to common education measurements, which are usually performed in several minutes, these magnetic materials have to be measured for several hours. Therefore an extra upgrade of this virtual system is planned. It will enable the client computer to send the task to the server computer that will initialize the measurements and store the measured values for further download by the client computer.

**REFERENCES**


