IMPLEMENTATION OF E-LEARNING PLATFORM FOR DISTANCE PRACTICAL EDUCATION IN ELECTRICAL ENGINEERING

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Abstract. Virtual and distance laboratories extend the application area of the web. This leads to an openly integrated environment which facilitates the sharing educational material, and also hardware and software resources. This paper investigates distance learning with particular attention to experimental work. The *PEMCWebLab* provides the user with a practical experience in electrical engineering education. It was designed based on leading ideas and had clear targets and offers a complete integrated solution for the education

Keywords: Distance education, Education, E-learning, Virtual laboratory

1. INTRODUCTION

Distance measurement in electrical engineering systems is used for several reasons [1]. Internet as well as local (LAN) computer network intranet makes it possible to create solutions useful for industry as well as education.

Industrial applications differ from the laboratory in the amount of data transferred, number of connected devices, length of bus (cable length) and number of measured signals.

The possibilities of using distance measurement in laboratory application are: PXI or VXI systems, GPIB interface or Data Acquisition Card. The card consists of several A/D converter coupled with an interface that allows a personal computer to control the actions of the A/D, as well as to capture the digital output information from a conversion.

Solutions used for laboratory applications and described bellow can use only a limited number of measurement instruments and number of controlled processes. Information transferred is usually simple. The GPIB interface (which is used in presented solution of distance laboratory) can connect max. 15 devices to the bus. The transfer speed is up to 1 MB/s and max length of the cable is 20 m. Therefore industrial solutions are based on different principles.

In the first part of the paper a distance measurement application for educational purposes is described. In the second part monitoring and industrial applications are studied.

2. ONLINE DISTANCE LABORATORIES

Online distance laboratories present the latest trend also in education. Therefore, for educational purposes, the hardware experiment should be adapted in such a way that it can also be accessed from the Web. In this way the advances in ICT will be combined with the real world.
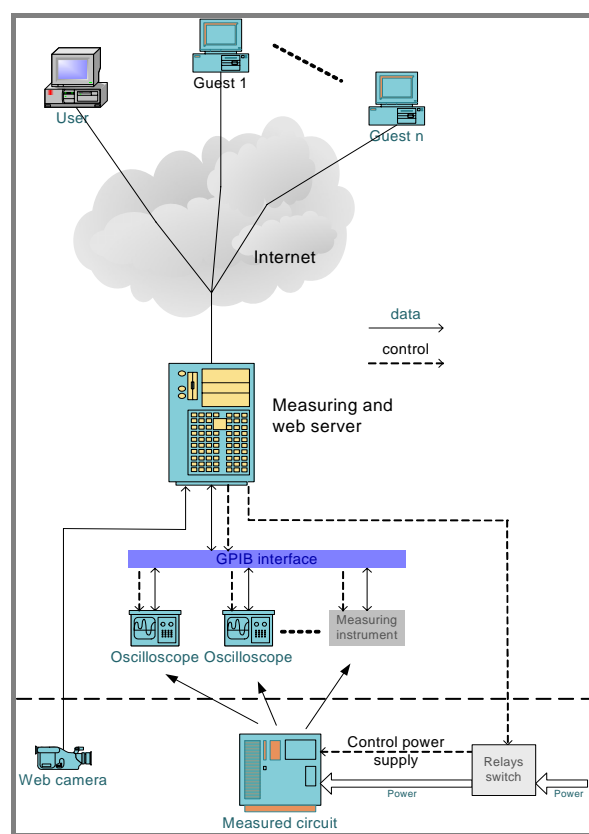

Fig. 1. Principal structure of considered distance laboratory with real experiments

The proposed virtual (distance) laboratory is not a web-based simulation. It is a *real electro-technical experiment* conducted in the laboratory, but it is remotely controlled and monitored by web-based tools. It is even possible to visualize the measuring instrument, the electronic components and many more factors such as lay-out, for example. This facility is useful to fulfill today's requirements for teaching over the Internet.

3. DISTANCE LEARNING

To support distance learning we developed a set of remotely controlled real experiments from fields of electrical engineering mainly from Power Electronics and Electrical Drives, so that they create the *PEMCWebLab*.

3.1 Integrated Learning System

The *PEMCWebLab* creates an integrated learning platform. Several learning issues are addressed such as:

- Learning objectives
- Education
- Animation
- Simulation
- Experiment

In the first part the Learning objectives of each experiment are addressed. In the part education a theoretical background of the each individual experiment is given. Interactive animations developed in the previous project are addressed further. The last educational method before experiment is the simulation.

The main function of *PEMCWebLab* is to provide a web-based remote control for designed experiments. The learning process includes several, specially designed, experimental tasks. However, for safety reasons no one will be allowed to perform any experiment until he, or she, has shown adequate knowledge of the experiment. Entering wrong input parameters, due to insufficient knowledge of the experiment, may also lead to improper operation of the experiment. Therefore, a learning routine is designed for learners to gain the prerequisite knowledge which is required before attempting the experiment.

After completion of the online experiment, the learners are given an opportunity to take a simple questionnaire or alternatively to submit their report through the available feedback subsystem for its final evaluation (depending on the requirement enforced by the instructor). All learning procedures are recorded for future reference and analysis.

3.2 Evaluation Subsystem

To use *PEMCWebLab* in order to achieve desired learning effect, the system first has to assess the learners' prerequisite knowledge of experiments. This is done throughout an evaluation subsystem before it permits the learners to access online experiments. Several types of evaluations are used in this system. The simplest method is to use a questionnaire that only contains true or false type questions, single questions, and multiple-choice questions. Instructors may also ask learners to submit simulation results or reports of the simulation tasks via e-mail, and then evaluate the results manually. Another possible method of online evaluation that is currently being considered is a peer review method. An experienced learner who has been trained can be assigned as a *Teaching Assistant* (TA) for that experiment. The TA can talks then to, or correspond with, anyone who requests permission to do that experiment. Once this TA believes that the new learner has adequate knowledge of the experiment, he or she can grant this learner access to that experiment. In this way the instructor's workload can be reduced.

3.3 Feedback Subsystem

A feedback subsystem plays an important role in improving the performance of the learners and the use of the *PEMCWebLab*. Feedback to learners often includes the evaluation results and suggestions on learning, while feedback to instructors and supervisors often includes problem reports on the *PEMCWebLab* and questions during the learning process. Peer or learner–instructor interactions are both significant in this feedback subsystem. In framework of the *PEMCWebLab* the authors have developed several feedback mechanisms. Feedback to learners may be provided instantly from predefined functions or from an instructor or administrator with a certain time delay. E-mail is one of the easiest ways for learners to communicate with instructors. Discussion forums or online chat rooms also provide different environments for the feedback.

4. EXPERIMENT ADMINISTRATION

Every experiment has its own server, because it is located at the different location. Remote users first log onto a main booking server, after which they will be directed to the specific server for actually performing the experiment.

4.1 Experiment Administration

A central booking system is available at the project page PEMCWebLab.com Booking system is provided through Moodle software. Layout of the Moodle pages for all experiments is uniform. This page will contain menu with the following submenus:

Submenu:

1. Learning objectives
2. Education
3. Animation
4. Simulation
5. Experiment

All the submenus at the booking system are to be accessed without restriction of number of students. The actual booking is provided in the *submenu Experiment*. The experiments can be booked one week ahead, the length of the offered time window for the experiment varies from 5 to 30 min. Before the experiment becomes available online, it should be tested to verify the correctness of the experiment results as well as the stability of the experimental set-up. The power to some experiment is available 24 hours a day; some experiments are available for safety reasons in the working hours only. An administrator of each experiment can restrict the use if the experiment for his purposes during some days or hours only. Supervisors have to routinely check the status of each experiment to make sure that each of them is functionally correct and is available for use.

Several clients can connect to PEMCWebLab.com simultaneously. However, Internet bandwidth becomes extremely limited when too many remote users request to

use this system. Several concurrent, remote users are allowed via an Internet connection for each experiment. However, each experiment in the *PEMCWebLab* can be operated only by a single remote user at a time. The system thus considers each experiment as a "resource", and remote users who wish to operate a specific experiment should first get permission to operate the experiment. Once the resource is in use, other remote users cannot access that resource, because it is then marked as "locked." All the remote users without access permission can see only the online, real-time video of that experiment.

4.2 Server Site Administration

As already said every experiment has its own server and it is located at the different location. Remote users first logged onto a main booking server, after which they will be directed to the specific server for actually performing the experiment get into the page of the experiment itself.

Fig. 2 Page of an experiment at the institution
5. A SET OF EXPERIMENTS IN FRAMEWORK OF THE PEMCWEBLAB

A Leonardo da Vinci EU project titled "*E-learning Distance Interactive Practical Education - EDIPE*" [2] is suggested and approved to create a full set of distance laboratories. Twelve universities with the span across the EU (from the countries: NL, F, D, PL, CZ, SK, HU, RO, GR) are participating in the project.

The expected specific results are:

- Learning objectives for the distance experimental education,
- The guidelines for project oriented measurements with the learning objectives for distance and /or virtual practical education,
- Synthesis oriented experimental measurements,
- Technology and technical documentation for distance practical education and measurements via the Internet,
- Different designed measurements each with its own philosophy.

The outputs from the project will present

- teaching material (in electronic form; guidelines, manuals, documentation in English and other languages),
- distance and virtual laboratories approached via web,
- visualisation and the layout of the measured system and
- the measurement results obtained via Internet.

The following modules are proposed (grouped into sets of modules) in such a way that they cover fundamentals and basic applications of the EE and advance topics including the application as well:

Groups of subjects – specialisation	Modules
1. Fundamentals of Electrical Engineering	1.1 Single Phase and Three Phase Rectifier Circuits 1.2 DC Circuit Measurements and Resonant AC Circuits
2. Power Electronics	2.3 Power Converters 2.4 Power Factor Correction 2.5 PWM Modulation 2.6 DC-DC Converter for Renewable Energy Sources and Microgrid 2.7 Power Quality and Active Filters 2.8 Power Quality and/or Electromagnetic Compatibility
3. Electrical Machines	3.1 Basic Electrical Machinery – Synchronous Generator 3.2 DC Machines 3.3 Basic Electrical Machinery – DC Motor 3.4 Basic Electrical Machinery – Asynchronous Motor
4. Electro-Mechanical and Motion Control Systems	3.1 Basic Elements of Internet based Tele-manipulation 3.2 Mechatronics, HIL (Hardware in the Loop) Simulation 3.3 High Dynamic Drives - Motion Control 3.4 A Automotive Electrical Drive 3.5 Complex Control of a Servodrive by a Small Logic Controller 3.6 Intelligent Gate Control by a Small Logic Controller (SLC)

Tab. 1 List of modules with remote controlled experiments in the EDIPE project
6. EXAMPLE OF THE WEB AND MEASURING PEMCWEBLAB SERVER

The main part of the system is the web server, which is responsible for all the web services, web pages and the correct functionality of the user interface. The web server also communicates with other applications which can access the other parts such as the measured data.

6.1 Measurement Application

Most of the similar applications use LabView [7]. In the case described here the measurement application communicates with measurement instruments via a GPIB interface. This application was written in a Matlab environment and finally compiled / built as an executable application. Matlab has to be installed together with its "Instrument Control Toolbox" to provide communication via the GPIB interface. This toolbox is a general programming interface, controlling all instruments equipped with a GPIB interface.

6.2 Control of Power Part

There is an application, programmed in C++ language, which controls the on and off switching of the power supply of the measuring instruments and the measuring board. The data bits of a parallel port are used as a control signal. A built-in remote controller controls the power switches by means of radio waves (see Fig. 3).
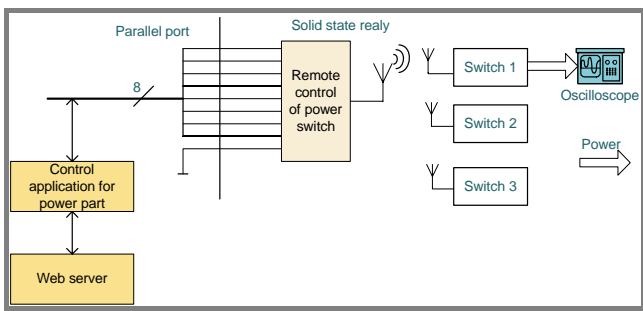

Fig. 3. Principle of power controlling

Compiler of the source code: The source-code compiler for the XC866 microcontroller is also included in this system. The usage of the compiler will be explained later. The selected microcontroller is a XC866 from Infineon [8]. This 8-bit microcontroller features a system on chip that has been developed for all kinds of motion control using PWM based schemes. The microcontroller used in this system is commercially available in an evaluation kit. The PC is connected to this starter kit via the communications port, COM1. After the user sends the source code to the microcontroller, it is compiled and translated to a hexadecimal-executable file and then loaded in the microcontroller. The programming language used for the microcontroller is C. Users can use all the available features of the C language and in addition they can also use the special registers as variables.

6.3 Software

The main functional part is the connection between the web server and the measuring applications which in turn communicate with the measuring devices themselves. In Fig.

4 (left) a simple state diagram of the web page is shown. The "*DelftWebLab page*" bubble represents the web page with measured data. From this page the user can run the measuring application (dash line). The two arrows pointing away from the "*DelftWebLab page*" bubble represent some events which might occur:

- The first event, namely the '*On change settings of the measurement instruments*', occurs when some parameters are changed e.g. the vertical scale of the scope, etc.
- The second event occurs periodically, refreshing the web page to show the latest measured data.

On the right side of this figure, there is a block diagram of a measurement cycle. The dashed line represents cooperation between the functionality of the web page and the measuring application. When the measuring application is launched, the program periodically controls the measuring instrument, reads the measured data and stores the measured data to a file.
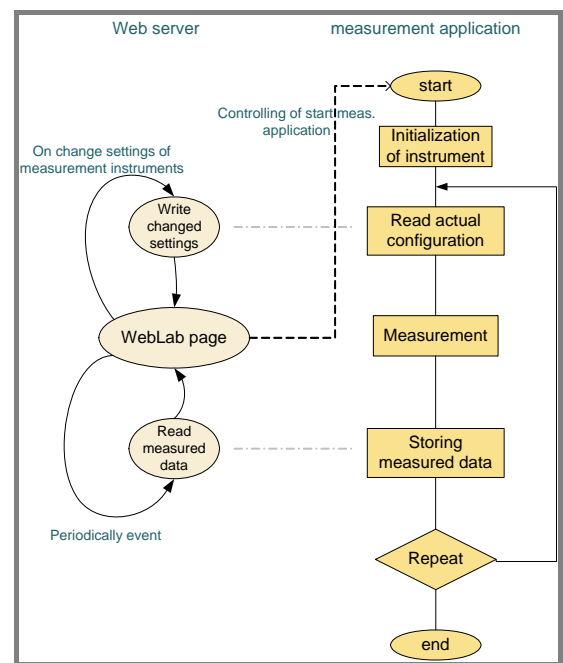

Fig. 4. Cooperation of the web server
and a measuring application

7. CONCLUSIONS

In this paper, we have introduced basic philosophy and structure of remote controlled laboratory - called the *PEMCWebLab*. It will collect real remote experiments from various application fields of Electrical Engineering.
Altogether 18 different experiments are under development. The course materials and case studies giving a guide to particular experiments will complement them in a short future. We will also welcome networking with other similar laboratories and interested colleagues abroad.

8. REFERENCES

[1] Ertugrul N.: Towards Virtual Laboratories: a Survey of LabVIEW-based Teaching/ Learning Tools and Future Trends.

[2] E-learning Distance Interactive Practical Education – EDIPE, Pilot Project of the EU Leonardo da Vinci Vocational Training Programme. Project No CZ/06/B/F/PP-168022, duration 10/2006 - 09/2008, at http://www.powerweblab.com/.

[3] Gillet D., Nguyen Ngoc A.V., RekikY.: Collaborative Web-based Experimentation in Flexible Engineering Education. IEEE Transactions on Education. No. 4 (2005). Vol. 48, p. 696-704.

[4] Cheng K.W.E, Chan C.L.,Cheung N.C, Sutanto D.: "Virtual Laboratory Development for Teaching Power Electronics, Power Elecgfonics and Motion Control Int. Conference, EPE-PEMC 2004 Riga, Latvia.

[5] Yi Z., Jian-jun J., Chun F.S.: A LabVIEW–based Interactive Virtual Laboratory for Electronic Engineering Education; Int. J. Engng Ed. Vol. 21, No. 1, pp. 94-103, 2005.

[6] Buckman A.B.: VI-Based Introductory Electrical Engineering Laboratory Course; Int. J. Engng Ed. Vol. 16, No. 3, pp. 212-217, 2000.

[7] Peek C. S., Crisalle, O.D., Deapraz S., Gillet D.: The Virtual Control Laboratory Paradigm: Architectural Design Requirements and Realization Through a DC-Motor Example; Int. J. Engng Ed. Vol. 21, No. 6, pp. 1134-1147, 2005.

[8] Fernandez C., Vicente M.A., Jimenez L.M.: Virtual Laboratories for Control Education: a Combined Methodology; Int. J. Engng Ed. Vol. 21, No. 6, pp. 1059-1067, 2005.

[9] Ertugrul N.: New Era in Engineering Experiments: an Integrated and Interactive Teaching/Learning Approach, and Real-Time Visualisations; Int. J. Engng Ed. Vol. 14, No. 5, pp. 344-355, 1998.

[10] Agelidis V.G.: A Laboratory-Supported Power Electronics and Related Technologies Undergraduate Curriculum for Aerospace Engineering Students, Int. J. Engng Ed. Vol. 21, No. 6, pp. 1177-1188, 2005.

[11] Gregson P.H., Little T.A.: Designing Contests for Teaching Electrical Engineering Design; Int. J. Engng Ed. Vol. 14, No. 5, pp. 367-374, 1998.

[12] Mann H., Ševčenko M.: Learning Dynamics and Control Using Remotely Tutored Simulation and Virtual Experiments. Conference IMCL2006. April 19 -21, 2006 Amman, Jordan.

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