REMOTE CONTROLLED PRACTICAL EDUCATION FOR POWER ELECTRONICS AND ELECTRICAL DRIVES

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INTRODUCTION

Distance learning has been promoted across the entire education sector due to the increasing number of people that educate themselves after their working hours or as part of their professional development. Furthermore, universities and high schools already use the Internet extensively for communication with their students. This, combined with the recent developments with regards to the Internet and information technology, has seen the need for web-based teaching grow rapidly.

Distance-learning, via the Internet, focuses on the delivery of information to the student, typically via web pages which are rich with multi-media content. The student, sitting at home in front of the computer, receives lessons in a certain subject while keeping contact with the other students as well as with the teacher via e-mail, chat-rooms, on-line tests, etc. Other issues focus on the style of teaching by using multi-media like video-clips, audio or “slide shows” extensively within the classroom, or alternatively from a distance (internet). Advanced educational material makes use of interactive programs, in the form of little experiments performed via a simulator or alternatively solving some engineering problems, in combination with the text explaining the theory.

The rapid changes in both society and technology have also created a demand for engineers that are more flexible – possess many more qualifications than just a high level of technical or scientific specialization. The drawback of a pure theoretical approach in an undergraduate electrical engineering (EE) curriculum is that less attention is paid to the phenomena that loom around laboratory experiments and the exploration of system components. The result of this, aided by the rapid development of computer applications, is that hands-on laboratory experience is vanishing and that computer simulations are receiving more and more attention.

However, it is crucial for students to gain this practical experience. Physical experiments give the students a feeling for practical testing. This also enables them to see the influence of second/higher-order, real-time and even parasitic effects which are often difficult or even impossible to simulate perfectly. The reason is that the simulations are always based on approximate or simplified models. Therefore it is important to give the students a real world experience. However, building an experiment is expensive and it is impossible for an educational institute to have the complete range of experiments. The hardware experiment should therefore 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. 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 fulfil today’s requirements for teaching over the Internet.

The experiments should not only be orientated to analysis (to measure and see the results) but also to synthesis. It should therefore include at least one design aspect. Therefore, the measurements are designed as a project based on a leading idea and with clear targets. First of all the technology of such an integration attempt, and thereafter guidelines to achieve distance Interactive Practical Education, are defined. This technology will be applied to the education of practical power electronics.

PEDAGOGICAL APPROACH

To support distance learning we develop a set of remotely controlled real experiments from fields of Power Electronics and Electrical Drives, so that they create PEMCWebLab. During its using in the pedagogical approach the learners and instructors interact with one another via three subsystems. These three subsystems will be discussed in this section.

Learning Subsystem

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

Evaluation Subsystem

To use PEMCWebLab to achieve the desired learning effect, the system first has to assess the learners’ prerequisite knowledge of the experiments. This is done through the evaluation subsystem before it permits the learners to access the 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 then talk 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.
Feedback Subsystem

A feedback subsystem plays an important role in improving the performance of the learners and the use of 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 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.

SYSTEM ADMINISTRATION

1) Experiment Administration: Every experiment has its own server (Fig. 1) because of the limited control ports available in an ordinary PC and also for easy maintenance. Remote users first log onto a main server, after which they will be directed to the specific server for actually performing the experiment.
Before an 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 the experiment is available 24 hours a day. 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.

2) Server Site Administration: The remote experiments offered on the Web can also be done locally, i.e., using the control programs on the server without connecting to the Internet.

3) Client Site Administration: Several clients can connect to PEMCWebLab 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 PEMCWebLab can be operated by only 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.

SET OF EXPERIMENTS IN FRAMEWORK OF THE PEMCWEBLAB

A Leonardo da Vinci EU project titled “E-learning Distance Interactive Practical Education - EDIPE” [3] 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), further distance and virtual laboratories approached via web, visualisation and the Lay out 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:

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
   2.1 Power Converters
   2.2 Power Factor Correction
   2.3 PWM Modulation
   2.4 DC-DC Converter for Renewable Energy Sources and Microgrid
   2.5 Power Quality and Active Filters
   2.6 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
   4.1 Basic Elements of Internet based Telemanipulation
   4.2 Mechatronics, HIL (Hardware in the Loop) Simulation
   4.3 High Dynamic Drives - Motion Control
   4.4 A Automotive Electrical Drive
   4.5 Complex Control of a Servodrive by a Small Logic Controller
   4.6 Intelligent Gate Control by a Small Logic Controller (SLC)

CONCLUSIONS

In this paper, we have introduced basic philosophy and structure of remote controlled laboratory called PEMCwebLab. It collects experiments from field of Electrical Engineering, Power Electronics, Electrical Machines, Electro-Mechanical and Motion Control Systems. Altogether 18 different experiments are under development. 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.

References


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