Description of the remote UTC-WebLaboratory for engineering education and interactive demonstration by online experiments

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***Abstract* - The paper describes the remote engineering laboratory for education (http://chem.engr.utc.edu) built by *Prof. Henry* since 1997 at the *University of Tennessee at Chattanooga (UTC)* and called in following shortly *UTC-WebLab.* Since several years *Prof. Zacher* used this WebLab for remote experiments teaching closed-loop control at Universities RheinMain and Darmstadt in Germany. In the interactive demonstration from Stockholm will be shown by one online experiment between Tennessee and Darmstadt, how the UTC-WebLab is used as a part of the cascade control loop, combined with the real devices of the labors of Prof. Zacher.**

***Index Term s* - controls, engineering, education, internet.**

I. INTRODUCTION

The efficiency of the online education via Internet was successfully proved by many projects, beginning from the first projects of the NSF (National Science Foundation of USA) like TICCIT (Time-shared Interactive Computer Controlled Information Television) and PLATO (Programmed Logic for Automated Teaching Operations) till nowadays.

There are known three kinds of Web-Laboratories:

- Remote laboratories, where users do experiments with real devices which are placed far from user.
- Virtualized laboratories, where instead of real devices students experiment with simulations.
- Partly virtualized laboratories, where real devices are combined with simulations.

The UTC-WebLab (WebLaboratory for control systems and process dynamics of the University of Tennessee at Chattanooga), developed and implemented by Prof. Jim Henry since 1997 is a remote laboratory, which provides experiments on the variety of feedback control systems, motor-generator systems, heat exchange, combustion, distillation, kinematics of machines, forced vibrations, batch drying and journal bearing pressure distribution and more [1]. Currently, the UTC-WebLab (*the web address http://chem.engr.utc.edu*) has had over 10,000 laboratory experiments per year conducted on shared equipment. All users of the UTC-WebLab without exception were fascinated by the opportunities of the remote experiments and were very motivated by their study.

II. DESCRIPTION OF UTC-WEBLAB

The main features of the remote laboratories for engineering education are:

- one user controls
- many users can observe simultaneously
- data saved for future review
- real plant subject to mechanical/electrical problems

The method of the data transfer, developed by the UTC-WebLab according to this, is shown in Fig. 1.

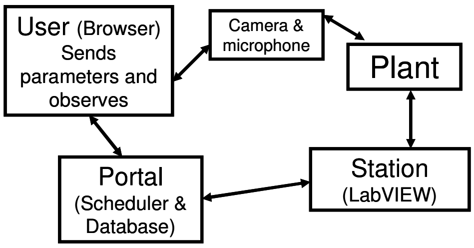

Figure 1. The Web method used by UTC-Weblab

An example of the realization is shown in Fig. 2. The air pressure control system consists of a 3-phase motor-driven blower fan forcing air into a system of ducts. The system has a variable-voltage, variable-frequency (VVVF) motor drive for the blower motor that is controlled by the data acquisition and control computer that is connected to the database server.

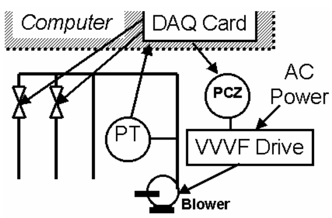

Figure 2. Schematic diagram of control system for air pressure

Eight other systems of the labor are described in [2] more completely, with diagrams, elsewhere.

III. Learning Strategy by Online Experiments

Since 2006, Prof. Zacher has used the UTC-WebLab together with his own laboratories of automation for his students at the Universities of Applied Sciences Rhein-Main and Darmstadt. From seven stations for controls systems experiments, which all are inherently stable systems when run in open-loop configuration, he used only the single-input single-output systems of speed and voltage control.

Later on Prof. Zacher expended the use of the UTC-WebLab for students of CDHAW (Chinesisch-Deutsche Hochschule für Angewandte Wissenschaften) and for master-of-science students in Electrical Engineering of ZFH (Zentralstelle für Fernstudien an FH in Koblenz).

In using the WebLab, each student receives a personal task with the different operation points of the plant, different sizes of the input step and sends the configuration via Internet to the UTC.

The step responses come back from UTC after 30-50 seconds as a text- and csv-file, which the students send to the EXCEL or MATLAB and evaluate. In addition to step response tests, ramp response, frequency response, pulse response and relay-feedback tests can be conducted for system identification. Proportional and proportional-integral feedback controllers can be run on all of the systems. Some systems have full proportional-integral-derivative (PID) feedback control capabilities.

Receiving the data files from the remote experiments at UTC, where the values of the input and output signals of the plant are represented in ASCII or text-format, students curry it out for process identification and modelling with MATLAB/Simulink, so that transfer functions will be achieved. The parameter estimation is done on the basis of the tangent method applied to the step response (Fig. 3). The complete example is described in [3].

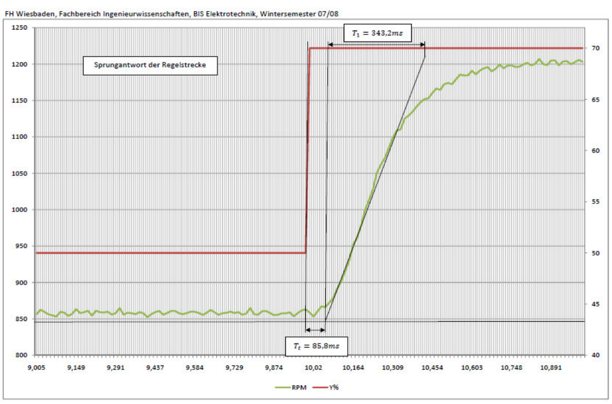

Figure 3. Plotted data resuting from one experiment

The important feature of the WebLab, mentioned above, is the fact, that the calculations results can not be exchanged between students, because each student receives own operating point, which demands his or her own calculation.

Another important feature of UTC-WebLabs, also mentioned above, is the access of each supervising professor to the databank and the possibility to follow the students results in the all experimental steps. The databank allows the search by names, by numbers of the experiments files or by date.

IV. Interactive Demonstrations

In the interactive demonstration from Stockholm will be shown by one online experiment between Tennessee and Darmstadt, how the UTC-WebLab is used as a part of the cascade control loop, combined with the real devices of the labors of Prof. Zacher.

The task of the student is to adjust the PI-controller in the main loop and the PD-T1 controller in the second loop, as shown in the block-diagram of the Fig. 4. The plant consists of two parts: one is in the laboratory at the University Darmstadt, the other should be identified by the step responses received from UTC-WebLab of Tennessee at Chattanooga. After evaluation of step responses as a P-T1- or P-T2-Plant the simulation model will be build and realized on the PLC.

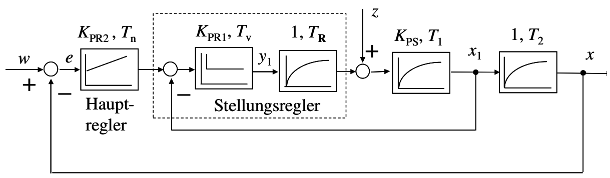

Figure 4. Block-diagram of the cascade control

The connection of two parts of the plant together and with both controllers, which are also programmed by the same PLC, results in a hardware-in-the-loop (HIL), which can be used for further experiments.

The future development should provide the possibility of a feedback from HIL to the UTC-WebLab to include the UTC-plant by the cascade control.

References

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