MATLAB Web Server and Web-based Control Design Learning

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Abstract – **In order to enhance learning of control design, minimise the gap between theory and practice and especially to support learning by doing we built two web-based laboratories. This paper presents the two web based laboratories: a MATLAB Web Server(MWS) based virtual laboratory for learning of control design and a remote laboratory. Using MWS based virtual laboratory, students could run prepared application as well as write their own MATLAB M-files and execute them using the MATLAB web server. The web-based remote laboratory is presented through a RC oscillator experiment for learning of control design. In RC oscillator experiment, interactivity between the controller design parameters in Bode plot and Root Locus with real experiment has been implemented in order to support full visualisation of the controller design.**

I. INTRODUCTION

The Internet (Web) has become a widespread tool for teaching and learning. The Web enables more flexible delivery (anytime), distance education (anyplace), new visualisation possibilities (interactivity), and cost reduction. Virtual and remote web-based laboratories [1 - 4, 7 –10] have been developed to date. Virtual laboratories are usually opened to the public. Remote web-based laboratories are based on sharing the same resources over the Internet [2, 3, 4]. Therefore, they are usually available only to a limited number of assigned students. In the paper two web-based laboratories are presented. The first one is a virtual laboratory for control design based on MATLAB Web Server (MWS). In this virtual laboratory students can use a structured application for control design as well as write their own MATLAB M-files and execute them using the MATLAB Web Server in order to design a control. The second web-based laboratory is a remote laboratory that supports the learning of control theory and control design. RC oscillator web-based remote control experiment is represented. For RC oscillator controller design, a visualisation of controller design parameters is implemented interactively with the remote control experiment. The objectives of our web laboratories are:

- to teach students control design,
- to minimize the gap between control theory and practice, by teaching control implementation [5, preface],
- to show students how to learn by Web and how to use it and
- to support learning by doing.

Among the teaching community a great variation of needs exists regarding the using of MATLAB Web Server. These variations stem from teacher's goals, students background knowledge and skills, the environment where the learning should take place and costs. Therefore some teachers welcome applications for hands-on experiments where no programming or math is needed to perform the experiment [7, 8, 9, 10]. Such hands-on experiments are fully structured and don't allow students to create experiments of their own. On the other side engineering education [11] must assure that young engineers posses the ability to design and conduct experiments, as well as to analyse and interpret data, and the ability to design a system, component, or process to meet desired needs. It is also not very likely that the problem students would have to solve in their professional carrier would fit into one of the structured exercises they learned at school. Taking into account these facts there is a permanent need in engineering education for less structured environments where students could build experiments of their own and practice design and data analyses and interpretation. Having in mind all this great variation of needs we built a virtual MWS based laboratory offering structured applications as well as unstructured ones for control design. An application allowing students to write their own MATLAB M-files and execute them using the MATLAB Web Server was built into our virtual laboratory. Only a virtual laboratory in [12] offers a similar unstructured environment. In section II our virtual MWS based laboratory for control design is described. Throughout our control courses we successfully used both environments to teach students control design.

When teaching control we should be aware of the gap between the theory and praxis [2, 5] and do our best to avoid this gap. More attention should be given to the control implementation details and their consequences in order to avoid the gap between the theory and praxis. Remote laboratory control experiments are the best means to consider control implementation details and their consequences using Web. An RC oscillator interactive experiment with control design visual support is presented in section III.

II. VIRTUAL MWS BASED LABORATORY FOR CONTROL DESIGN

The MATLAB Web Server (MWS) was designed to create MATLAB applications that use the capabilities of the World Wide Web to send data to MATLAB for computation and to display the results in a Web browser. The MWS depends

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upon TCP/IP networking for transmission of data between the client system and MATLAB. We use the simplest configuration where a Web browser runs on a client Personal computer (PC) while the MATLAB Web Server and the Web server daemon run on the server machine.

MATLAB Web Server applications are a combination of M-files, HTML documents and graphics. Two HTML documents are needed. The first HTML document collects the input data from the user, sends them to the MWS and runs a M-file needed for the application. The M-file needed for the application resides permanently on MWS, in the following we will refer to it as an application M-file. The application M-file reads input data collected by the first HTML document from a MATLAB structure, performs requested operations, generate requested graphics and places the output data into the MATLAB output structure. The second HTML documents gets results from the MATLAB output structure and displays them on the client machine. For detailed information see MATLAB Web Server Documentation.

In the following we will refer to the previously described applications as the standard MATLAB Web Server applications as opposed to M-file MATLAB Web Server application (also M-file application for MWS).

For the purpose of control design learning a standard MWS application called Web Sisotool was build.

A. Web Sisotool – standard MWS application

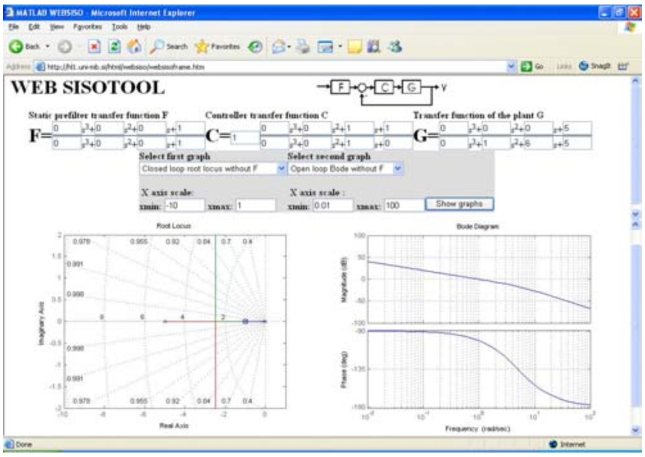
Web sisotool application is a standard MWS application. It is an example of application for learning of control design. The idea for the application comes from MATLAB's tool called sisotool. For Web sisotool application the order of the transfer functions F, C, and G is limited to order three in order to keep input data and results visible on one web page. It was agreed that currently third order of transfer functions is sufficient for introduction to control. Two graphs – results are obtained at the same time (see Fig.1). On the graphs between time response, rootlocus or bode plot could be selected. Interactivity of Web sisotool application is constrained in comparison to MATLAB's locally run sisotool to variation of transfer function parameters because figures obtained from MWS are frozen. It is an easy to use control design tool.

B. M – file applications for MWS

The aim of the M-file MWS application is to allow our students creating their own control experiments by writing their own M-files and sending them to MWS for execution. Students (user) obtain the results over the Web. The concept of our solution is to build one standard MATLAB Web Server application that would serve for the upload and execution of user 's M-files. Our desire was to implement the solution that would use the same programming code for M-file MWS application as it is used for execution of M-file with MATLAB locally. It should be noted that all user data should be defined inside the user M-file. Further we accepted a constraint that only transfer function objects and one Figure per user M-file are allowed. All variables used by M-file MWS application could be displayed after execution is finished.

For the implementation of the M-file MWS application we chose PHP programming language and MySQL database. PHP language was chosen because it could be mixed with the HTML language.

Fig.2 shows a diagram of M-file MWS application implementation.


MATLAB WEBSISO - Microsoft Internet Explorer

http://hl1.uni-mb.si/html/websiso/websisoframe.htm

WEB SISOTOOL

Static prefilter transfer function F

Controller transfer function C

Transfer function of the plant G

Select first graph: Closed loop root locus without F

Select second graph: Open loop Bode without F

X axis scale: xmin: -10 xmax: 1

X axis scale : xmin: 0.01 xmax: 100

Fig. 1: Web version of Sisotool from MATLAB

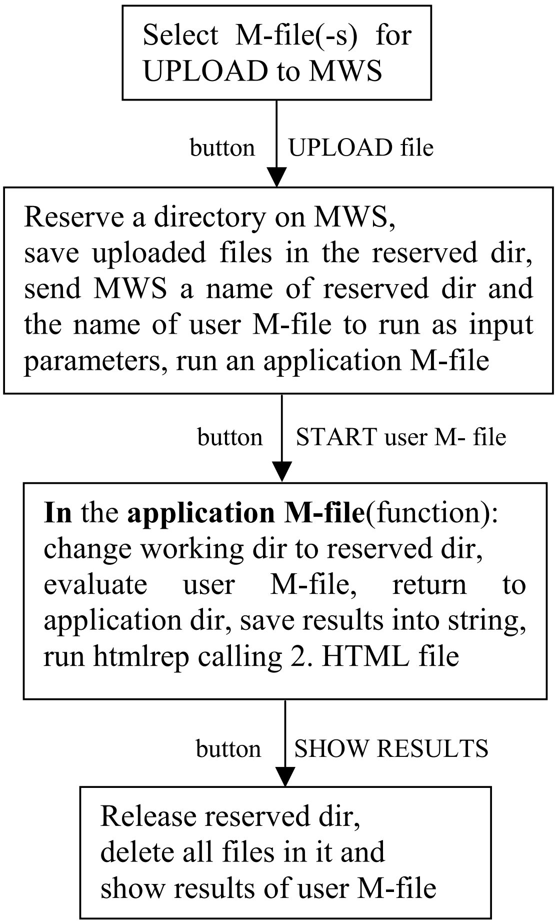

Select M-file(-s) for UPLOAD to MWS
button
UPLOAD file
Reserve a directory on MWS, save uploaded files in the reserved dir, send MWS a name of reserved dir and the name of user M-file to run as input parameters, run an application M-file
button
START user M- file
In the application M-file(function): change working dir to reserved dir, evaluate user M-file, return to application dir, save results into string, run htmlrep calling 2. HTML file
button
SHOW RESULTS
Release reserved dir, delete all files in it and show results of user M-file

Fig.2: M-file application implementation for MWS

For the standard MWS application two HTML files are needed and the application M-file. The task of the first HTML file is to collect data from user, send data to the MWS and run the application M-file on MWS. In our solution we replaced the first HTML file with two PHP files. The task of the first PHP files is to upload necessary user M-files. It is possible to upload up to three user M-files to the MWS at the same time if needed. The second PHP file serves for the reservation of user directory on MWS, for saving of uploaded user M-files to the user directory, for sending a user directory name and a name of user M-file to be executed as application data and to run the application M-file on MWS.

On MWS there is a limited number (temporary 15) of user directories available. The reservation of user directories is based in general on the user TCP/IP address and on MySQL database. Only one user could access MySQL database at the same time therefore two users cannot reserve the same user directory. In MySQL database the information whether the user directory is reserved or not, TCP/IP address of the user who reserved the directory and the time of the last file upload to the MWS is stored. To active users the same user directory is assigned on the subsequent uploads of user M-files on MWS. Reservation of the user directory of a passive user is canceled automatically if the subsequent user M-file upload does not follow in 15 minutes. If the user tries to reserve a directory when all user directories are reserved, the user is asked to try later. After the user has reserved the user directory all user's M-files are saved on it. And finally the execution of the application M-file is started and names of the user directory and of the user M-file to be executed are sent to it as application input data. In the case of two or three user M-files uploaded to MWS the user M-file to be executed is always the M-file uploaded with number 1. The remaining uploaded user M-files had to be called from the user M-file to be executed or they have no action.

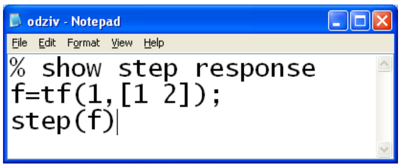
The application M-file is a MATLAB function. In the application M-file MATLAB identification number and names of the application directory, the user directory and the user M-file to be executed are read from the input structure first. Then the directory is changed to the user directory and the user M-file to be executed is evaluated. To save results the directory is changed to the application directory and results are saved in a string named s. At the end the second HTML file is called using htmlrep function and an output string s with results is sent to it.

In our solution the second HTML file notifies the user that the MATLAB has had finished the execution and calls the third PHP files. The third PHP file releases the reserved user directory, deletes all user M-files and displays results.

Fig. 3,4,5,6,and 7 show the whole M-file application as is seen by the user on the browser when using MWS. In Fig. 3 a simple code named odziv for calculation of step response written in text editor Notepad is shown. In Fig.4 the web page for upload of M-files is presented. Fig. 5 and 6 show the web page for start of execution of M-file odziv and for final display of results. And in Fig.7 the resulting step response in form of a Figure is shown. Bode, rlocus or any other MATLAB command could replace the step command.

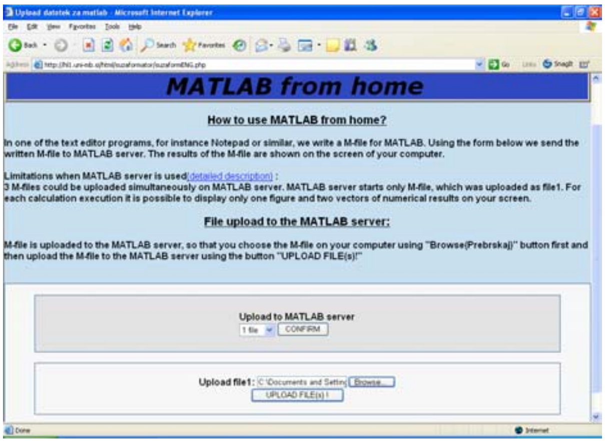
The Internet address of the MWS based virtual laboratory is http://hl1.uni-mb.si/.

The main drawback of a similar solution of M-file application in [12] is that M-files written must modified for the application and cannot be used directly by the MATLAB running locally on a computer.



```
% show step response
f=tf(1,[1 2]);
step(f)
```

Fig.3: M-file for step response called odziv


Upload datotek za matlab - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites
Address http://hl1.uni-mb.si/html/suzaformator/suzaformENG.php
Go Links SnagIt
Done
Internet

MATLAB from home

How to use MATLAB from home?

In one of the text editor programs, for instance Notepad or similar, we write a M-file for MATLAB. Using the form below we send the written M-file to MATLAB server. The results of the M-file are shown on the screen of your computer.

Limitations when MATLAB server is used(detailed description) :
3 M-files could be uploaded simultaneously on MATLAB server. MATLAB server starts only M-file, which was uploaded as file1. For each calculation execution it is possible to display only one figure and two vectors of numerical results on your screen.

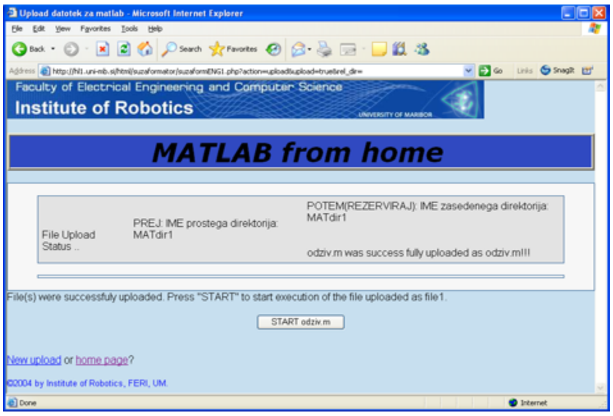
File upload to the MATLAB server:

M-file is uploaded to the MATLAB server, so that you choose the M-file on your computer using "Browse(Prebrskaj)" button first and then upload the M-file to the MATLAB server using the button "UPLOAD FILE(s)!"

Upload to MATLAB server
1 file CONFIRM

Upload file1: C:\Documents and Settin Browse...
UPLOAD FILE(s) !

Fig.4: M-file upload to MATLAB Web Server


Upload datotek za matlab - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites
Address http://hl1.uni-mb.si/html/suzaformator/suzaformENG1.php?action=upload&upload=true&rel_dir=
Go Links SnagIt
Faculty of Electrical Engineering and Computer Science
Institute of Robotics
UNIVERSITY OF MARIBOR
Done
Internet

MATLAB from home

File Upload Status ..

PREJ: IME prostega direktorija: MATdir1

POTEM(REZERVIRAJ): IME zasedenega direktorija: MATdir1

odziv.m was success fully uploaded as odziv.m!!!

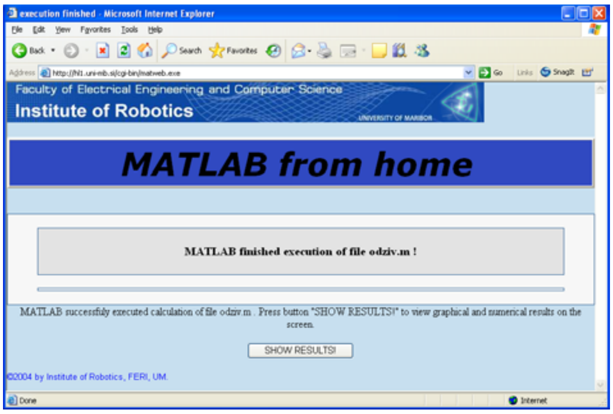
File(s) were successfuly uploaded. Press "START" to start execution of the file uploaded as file1.

START odziv.m

New upload or home page?

©2004 by Institute of Robotics, FERI, UM.

Fig.5: Start MATLAB Web Server execution of odziv


execution finished - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites
Address http://hl1.uni-mb.si/cgi-bin/matweb.exe
Go Links SnagIt
Faculty of Electrical Engineering and Computer Science
Institute of Robotics
UNIVERSITY OF MARIBOR
Done
Internet

MATLAB from home

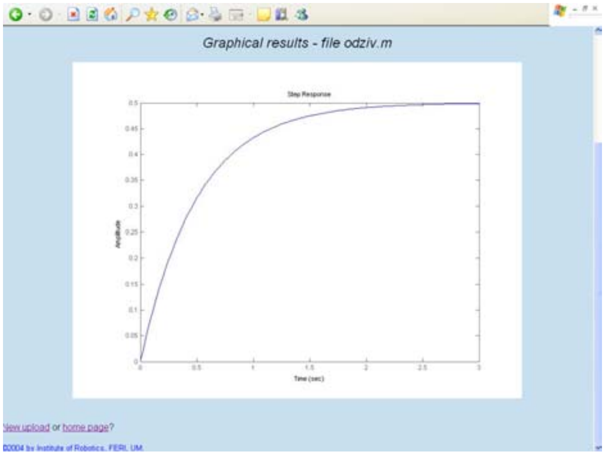
MATLAB finished execution of file odziv.m !

MATLAB successfuly executed calculation of file odziv.m . Press button "SHOW RESULTS!" to view graphical and numerical results on the screen.

SHOW RESULTS!

©2004 by Institute of Robotics, FERI, UM.

Fig.6: MATLAB Web Server execution finished



Graphical results - file odziv.m

Fig.7: Step response of M-file odziv

III. REMOTE LAB AND CONTROLLER DESIGN

A remote lab at Faculty of Electrical Engineering and Computer Science, University of Maribor was established in order to support the learning of control. This remote lab provides various remote experiments (cascade control of DC motor, two axes mechatronic device control, RC oscillator). Remote lab experiments are available on: http://remotelab.ro.feri.uni-mb.si/eng/experiments.asp.

The RC oscillator is a web-based version of interactive controller design and experiment (in the following WICDE). The RC oscillator experiment is used in an introductory control course at our faculty. The objectives of WICDE are:

- to teach students control design,
- to minimize the gap between control theory and practice, by teaching control implementation [5, preface],
- to show students how to learn by Web and how to use it and
- to support learning by doing.

The WICDE was designed to be available to a broad range of our students. Therefore, it was designed with minimum software requirements from the students prospective. To perform the WICDE experiment, a standard web browser (Internet Explorer, Mozilla, etc.) and 'LabVIEW Run Time Engine' are needed. Unfortunately, the assumption of minimum student's software requirements sets an undesirable limitation on the implementation of 'Learning through doing'. This limitation means that students can not build their own experiment but could only vary the parameters of the already prepared experiment. Such a limitation is widely accepted for web-based experiments. Only a web-based experiment presented in [3] assumes the MATLAB/Simulink software environment to be possessed by the students. Therefore, in the case of the web-based experiment in [3], students could build their own experiment from home.

A. System architecture of WICDE

WICDE is implemented using a DSP-2 learning module, and a breadboard with an RC circuit (Fig. 8). The DSP-2 learning module is an 'embedded', light and small in volume DSP-based control system. It was developed at the Faculty of Electrical Engineering and Computer Science, University of Maribor. The DSP-2 learning module is presented in detail on the address: http://www.ro.feri.uni-mb.si/projekti/dsp2.

The DSP-2 learning module represents an open framework for rapid control prototyping (RCP) and rapid remote control experiment development. Fig.10 presents the block scheme of the DSP-2 learning module-based remote laboratory. A DSP-2 learning module, connected to a lab PC through the serial port, implements a control algorithm developed using Simulink [6], and through the analog and digital I/O signals, drive the real plant. LabVIEW virtual instrument and the LabVIEW server run on the same lab PC for the purpose of enabling remote control of the real plant. LabVIEW VI performs communication between the lab PC and the DSP-2 learning module, and enables DSP-2 data visualization and parameter tuning, while LabVIEW server enables remote operation of the LabVIEW VI. Remote users, connected to the server through the Internet, must have a 'LabVIEW Run-Time Engine' installed on their personal computer in order to perform remote experiments. During remote experimentation, the remote user can adjust the controller parameters and send experimental results via email.

The DSP-2 learning module-based RCP system is based on two commercially-available software packages i.e. MATLAB/Simulink and LabVIEW, and custom-made hardware i.e. DSP-2 learning module. MATLAB, Simulink and Real-Time Workshop (RTW) are used for control algorithm development, simulation, offline analysis and rapid executable code generation [6], while the LabVIEW provides on-the-fly data visualization and parameter tuning tasks. LabVIEW virtual instrument (VI) is automatically generated during the binary code generation process, from Simulink model, where the user front end of created VI depends on special DSP-2 blocks used in the Simulink model. Using Remote Panels (LabVIEW add-on toolkit), generated VI's can be easily viewed and controlled over the Internet. LabVIEW VI's can be published on the Internet with no additional programming and can be remotely observed or controlled by using only the standard web browser.

B. RC oscillator control experiment

RC oscillator experiment is implemented using a DSP-2 learning module, and a breadboard with an RC circuit (Fig. 8). The resistor and capacitor values of the RC circuit are:

$$R1 = R2 = R3 = R = 47\ \text{k}\Omega,$$
$$C1 = C2 = C3 = C = 1\ \mu\text{F}.$$

A control loop of the RC oscillator is shown in Fig. 11. Mathematical model (transfer function) of the RC circuit is given by equation (1).

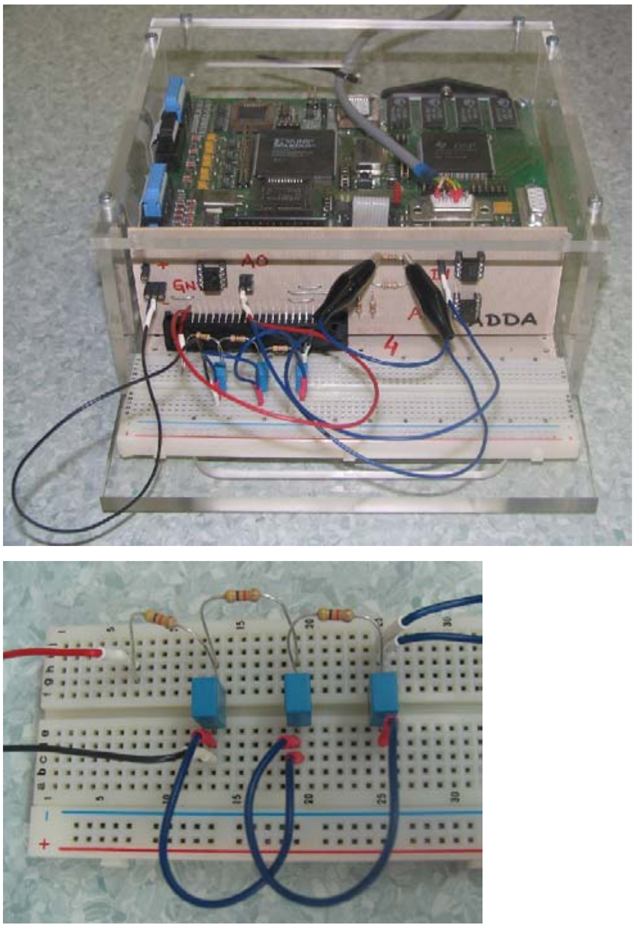


Fig. 9: DSP-2 learning module with RC circuit on the breadboard

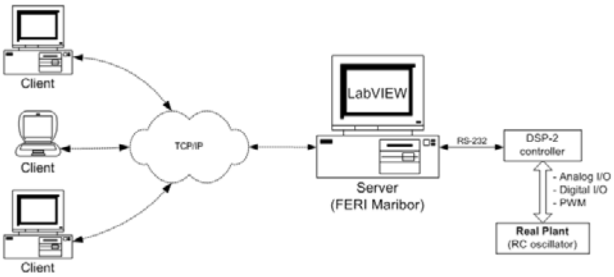


Fig.10: DSP-2 based remote laboratory block scheme

$$F_{RC}(s) = \frac{U_{out}(s)}{U_{in}(s)} =$$

$$= \frac{1}{(R \cdot C)^3 \cdot s^3 + 5 \cdot (R \cdot C)^2 \cdot s^2 + 6 \cdot (R \cdot C) \cdot s + 1} \qquad (1)$$

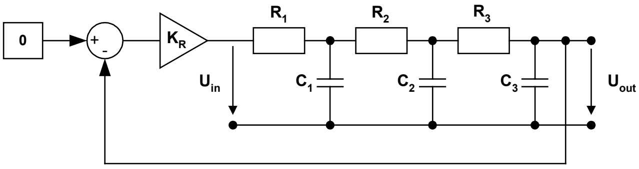


Fig. 11: RC oscillator control loop

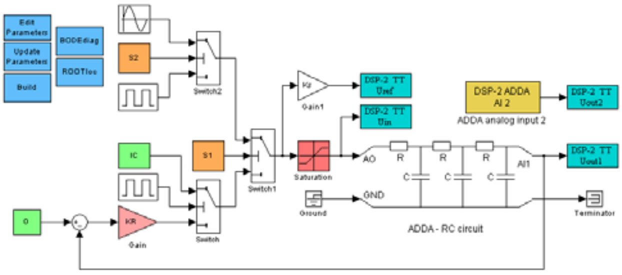
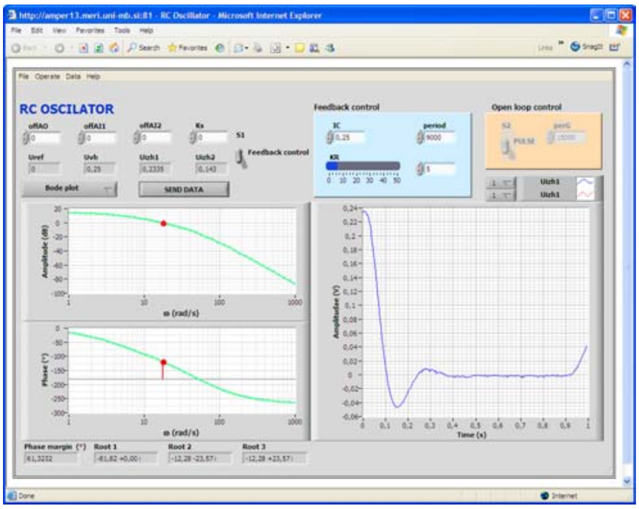


Fig. 12: Matlab/Simulink block scheme for RC oscillator

The MATLAB/Simulink scheme implemented for the WICDE RC oscillator is shown in Fig. 12. The open-loop control of RC circuit and feedback control of RC circuit are combined in one Simulink block scheme. Switch S1 is used to select between open-loop or feedback control. When open-loop control is selected switch S2 is used to select the step or the sinusoidal input to the RC circuit. When feedback control is selected another switch takes action. This switch selects between the initial condition (IC) input and feedback with gain K_R for input into the RC circuit. Therefore two phases of the RC oscillator response are observed. The capacitors of the RC circuits are charging to the value IC when IC input is selected. This phase is called the ‘charging phase’. When feedback with gain K_R is selected the RC oscillator response is observed. This phase is called the ‘RC oscillator relaxation phase’. Signals Uref, Uin, Uout1 and Uout2 from the Simulink block scheme could be observed. Online tuning of the K_R (RC oscillator feedback gain), IC (the value to which capacitors should charge) and per the period of the pulse generator switching between the charging and the relaxation phase is possible. Due to delays appearing in Internet connections, delays also appear between the variation of the gain K_R and the interactive view of the RC oscillator response.

The RC oscillator Bode plot or Root Locus plot can be observed interactively with the RC oscillator response. Both mentioned plots are calculated by MATLAB on the basis of the RC circuit transfer function given in (1). Controller design parameters, such as phase margin and crossover frequency, are clearly marked in the Bode plot. Accordingly in Root Locus the actual roots of the control loop are clearly marked. Bode plot or Root Locus design is selected with the left button above the design diagrams in the LabVIEW front panel (Fig. 13 and 14).



http://amper13.meri.uni-mb.si:81 - RC Oscillator - Microsoft Internet Explorer

RC OSCILATOR

offAO	offAI1	offAI2	Ks
0	0	0	0

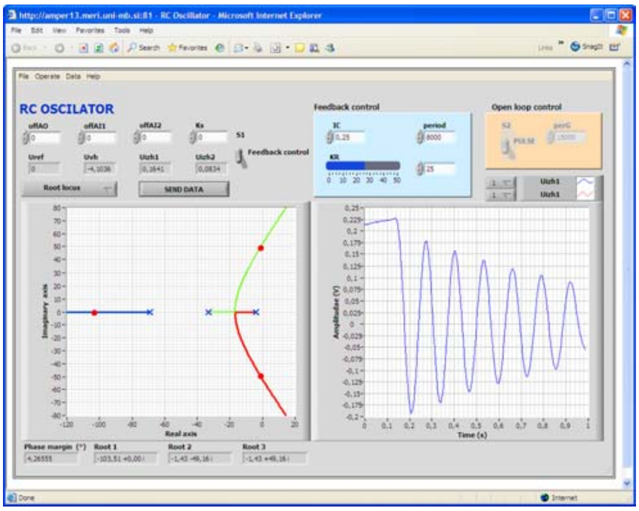
Uref	Uvh	Uzh1	Uzh2
0	0,25	0,2335	0,143

Feedback control: IC 0,25; period 9000; KR 5

Open loop control: S2 PULSE; perG 15000

Phase margin (°)	Root 1	Root 2	Root 3
61,3232	-81,82 +0,00 i	-12,28 -23,57 i	-12,28 +23,57 i

Fig.13: Bode plot design with interactive experiment (K_R = 5)



http://amper13.meri.uni-mb.si:81 - RC Oscillator - Microsoft Internet Explorer

RC OSCILATOR

offAO	offAI1	offAI2	Ks
0	0	0	0

Uref	Uvh	Uzh1	Uzh2
0	-4,1036	0,1641	0,0834

Feedback control: IC 0,25; period 8000; KR 25

Open loop control: S2 PULSE; perG 15000

Phase margin (°)	Root 1	Root 2	Root 3
4,26555	-103,51 +0,00 i	-1,43 -49,16 i	-1,43 +49,16 i

Fig. 14: Root Locus method design with interactive experiment (K_R=20)

C. Learning of control using RC oscillator experiment

Considering learning in the class then WICDE is suitable only as a means for demonstrations done by the lecturer. The reason for this is the limitation of resources (one device – one user) inherently given by every remote experiment. But on the other side WICDE excellently supports individual assignments for the students and learning by doing over the web. One form of individual assignments for the students is homework. In this school year we designed a homework task to be performed using the RC oscillator experiment and give it to the students taking part in the introductory control course at our faculty. Experiences gained are represented.

Short description of homework task: Use WICDE to design a P controller with gain K_R using Bode plot for RC oscillator. RC oscillator is used for generation of sinusoidal signals, therefore design gain K_R for the margin of stability. Verify your Bode plot design by the time response experiment. Observe the Bode plot and time responses of the RC oscillator at K_R =3.2, 10, 25 and 40 and determine the phase margin at given gains. Compare the results obtained from the WICDE with results obtained using Web sisotool or M-file application for MWS and explain reasons for deviations if any. Using WICDE find out how are the overshoot of the RC oscillator time response and phase margin in the Bode plot dependent on the gain K_R.

IV. CONCLUSION

To support learning by doing of our students at home we built MWS applications Web sisotool and M-file application and remote laboratory. The MWS M-file application enables students to create their own virtual experiments by writing their own MATLAB M-files and executing them using MATLAB web server. Only [12] offers similar MWS M-files application and unstructured experimental environment.

For controller design, a visualisation of controller design parameters interactively with the control loop step response is important. In MATLAB, the environment sisotool offers such visualisation capabilities for simulated control loops. In RC oscillator experiment interactivity between the controller design parameters in Bode plot and Root Locus with real experiment has been established. According to our knowledge none of the web-based experiments [2, 3, 4] incorporates controller design interactive with experiment. More remote experiments are planned.

V. REFERENCES

[1] S. Dormido, "Control Learning: Present and Future", In Proc. 15th IFAC World Congres on Automatic Control,Barcelona, Spain, 2002

[2] C. Schmid, "Internet-basiertes Lernen", *Automatisierungstechnik*, vol. 51, No. 11, 2003, pp. 485-493.

[3] M. Casini, et all, "The Automatic Control Telelab", *IEEE Control Systems Magazine*, vol. 24, No. 3, 2004, pp.36-44.

[4] H. Hoyer et all, "A multiuser Virtual-Reality Environment for a Tele-Operated Laboratory" ", *IEEE Trans. on Educ* , vol. 47, No. 1, 2004, pp. 121-126.

[5] G. Ellis, Control System design guide, A Practical Guide, Elsevier Academic Press, 2004.

[6] D. Hercog, K. Jezernik: "Rapid Control Prototyping using MATLAB/Simulink and DSP-based Motor Controller", *International Journal of Engineering Education (IJEE)*, Vol. 21, No. 4, 2005

[7] B. Wittenmark et all., "Dynamic Pictures and Interactive Learning," *IEEE Control Systems*, vol. 18, pp. 26–32, June 1998.

[8] B.L. Sturm and J.D. Gibson, "Signals and Systems Using MATLAB: An Integrated Suite of Applications for Exploring and Teaching Media Signal Processing," Proceed. 35th ASEE/*IEEE Frontiers in Education Conf.*, pp. F2E-21–F2E-25, Oct. 2005, Indianapolis, USA, Indiana .

[9] M. de Magistris, "A MATLAB-Based Virtual Laboratory for Teaching Introductory Quasi-Stationary Electromagnetics," *IEEE Trans. on Educ.*, vol. 48, pp. 81–88, Feb. 2005.

[10] J. Sanches et all., "Easy Java Simulations: an Open-Source Tool to Develop Interactive Virtual Laboratories Using MATLAB/Simulink," *Int. J. Engineering Educ.*, vol. 21, No.5, pp. 798-813, Sept. 2005

[11] S.D. Creighton et all., "A Comprehensive System for Student and Program Assessment: Lessons Learned," *Int. J. Engineering Educ.*, vol. 17, No. 1, pp. 81-88, January 2001

[12] M. Sysel and I. Pomykacz, "Extension of MATLAB Web Server," Proceed. 35th IASTED Int. Conf. Advances in Computer Science and Technology, pp. 70–74, Nov. 2004, St.Thomas, US Virgin Islands.

[13] A. Valera et all., "Virtual and Remote Control Laboratory Development," *IEEE Control Systems*, vol. 25, pp. 35–38, Feb. 2005.