E-Learning Practical Teaching of Resonant AC Circuits

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Abstract *– The paper presents hardware and software aspects regarding an E-learning approach of resonant ac converters. Built on LabVIEW and accompanied by a switching board interface, the setup allows a comprehensive study by remote controlling and performing real measurements on converters. The study is offered in a gradually manner, with theoretical aspects and simulation first, in the end the real experiments being investigated.*

Keywords: *Autonomous learning environment, remote experimentation, computer aided instruction, LabVIEW, series resonant converter (SRC), LCC converter.*

I. INTRODUCTION

Many teachers continue to think their main duty is to transfer their knowledge to the students by giving lectures or by organizing laboratory experiments. In this view, the accent is on *teaching*, rather on *learning*. Presently, the new philosophy is to assume that knowledge is not transferred, but that the learner himself constructs knowledge on the basis of prior knowledge and additionally acquired information. "Learning by doing" or "Learning by experimenting" approaches are accompanied by an output oriented curricula as part of the shift emphasis from teaching to learning. This view is referred to as constructivism and neoconstructivism [1], [2]. While in the teaching-oriented approach the student is rather passive, in the vision of learning-oriented the student plays an active role, constructing knowledge on the basis of prior knowledge and additionally acquired information, with teaching as a facilitating precondition.

Efficient learning in engineering assumes a mixture between theory and practical work. For engineering related distance education the use of a web-based delivery mechanism is the only realistic method for providing hands-on experience, allowing remotely located students to complete laboratory assignments, unconstrained by time or geographical considerations. They can change parameters, perform experiments, observe results in graphical or numeric form and download them.

The learning process in power electronics includes all important steps: general theory, key design factors (device stresses, ripple estimation, waveforms, power quality aspects, etc.), simulation and real experiment measurements [3].

The application presented in this paper describes LabVIEW-based blended E-learning approach to teaching resonant ac circuits in the Leonardo da Vinci EDIPE (E-learning Distance Interactive Practical Education) program framework. Studying and experimenting access is opened for 24 hours a day, 7 days a week. The Leonardo da Vinci project EDIPE is approved to create a full set of distance experiments called PEMCWebLab in an integrated learning platform, providing the user with a practical experience in Power Electronics and Electrical Drives education. They are real experiments, remotely accessed, controlled and monitored. The participants are twelve universities from EU countries.

The course module "Resonant AC Circuits" is dedicated to bachelor students and anyone interested in understanding resonant converters operation with emphasis on good matching between theory and practice. The aim of the course is to explain and practice the basic principles of soft switching in basic resonant topologies. Because the practical experiments follow a simulation stage, the student is able to notice all the similarities and discrepancies between theory and practice.

II. GENERAL DESCRIPTION AND HARDWARE ARHITECTURE

The main system architecture is presented in Fig. 1. The Moodle open source program was chosen for booking and the local server uses LabVIEW [4] for controlling the experiment. The Web Publishing Tools that come with LabVIEW are used both for interfacing and remote controlling the experiment, namely to choose the converter type, select the desired waveforms and perform different measurements.

The hardware architecture is presented in Fig. 2. The PCI-MIO-16E-1 DAQ card together with the SCB-68 shielded I/O connector block for DAQ devices are used for acquisition and measurements. The Switching Board Interface (SBI) is controlled from LabVIEW 8.5 and is used for configuring the desired converter topology and

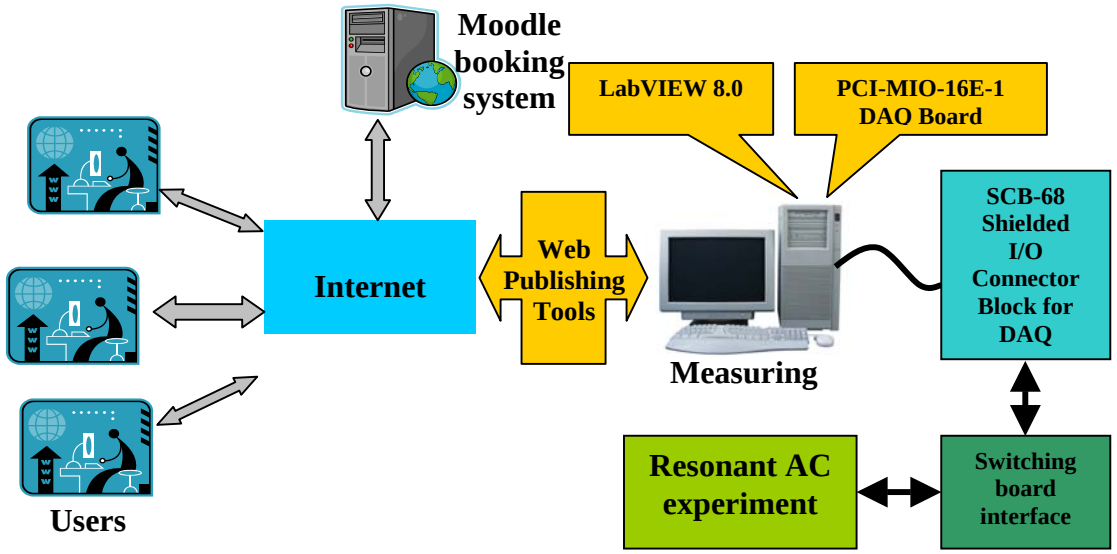

Fig. 1. Structure of the distance laboratory for E-learning practical teaching of uncontrolled rectifiers.

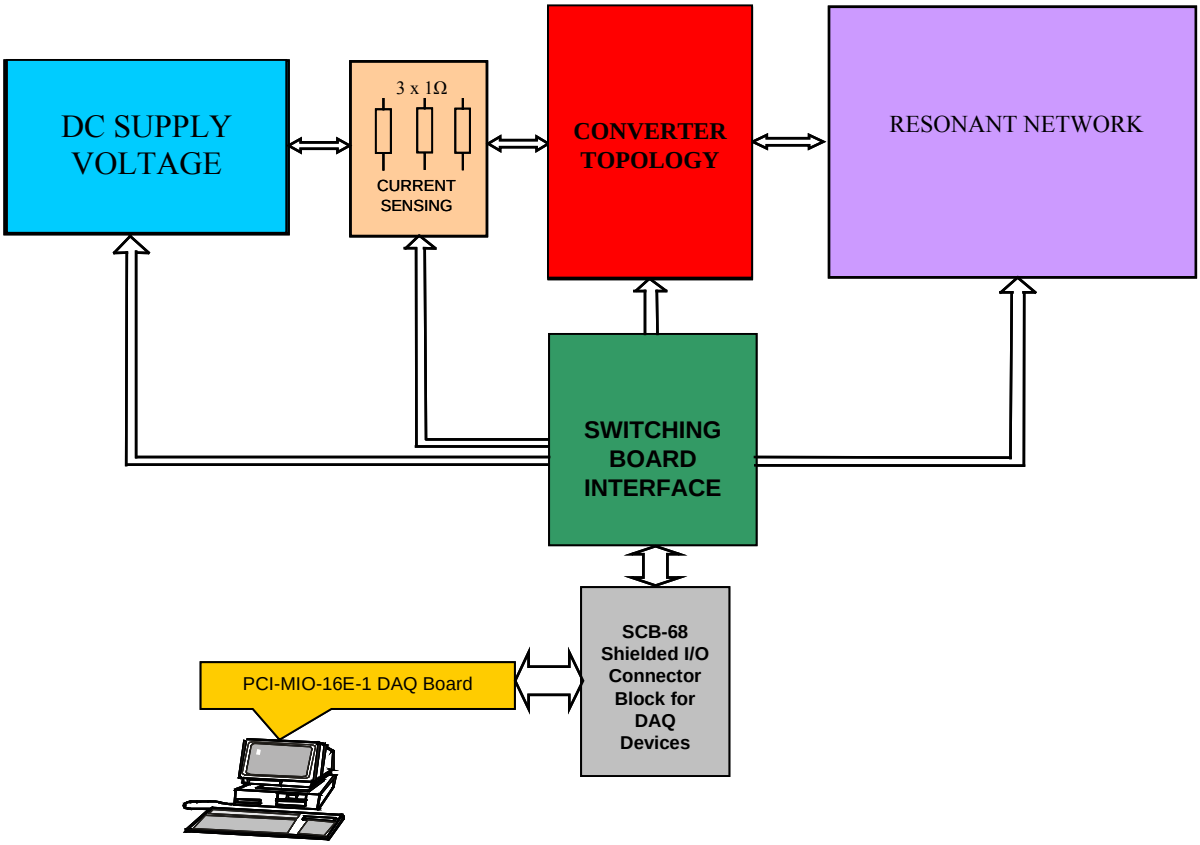

Fig. 2. Hardware architecture of the "Resonant AC Circuits" module.

signals acquisition.

Functionally, the switching board consists of a 32 bit shift register followed by buffers that switch on and of a relay matrix. In order to ensure safe operation, the order the relays are switched is important. This is achieved sequentially writing 32-bit words in the shift registers using outputs O_1, O_2, O_3. The relays are used both to obtain the desired converter configuration and to provide to the acquisition board the signals of interest. They are also used to switch on and off the dc input voltage.

The LabVIEW main program permanently monitors the user's connection state according to the flow chart depicted in Fig. 3. If the remote panel window is closed without normally exiting the program, the experiment would remain permanently connected, which can be

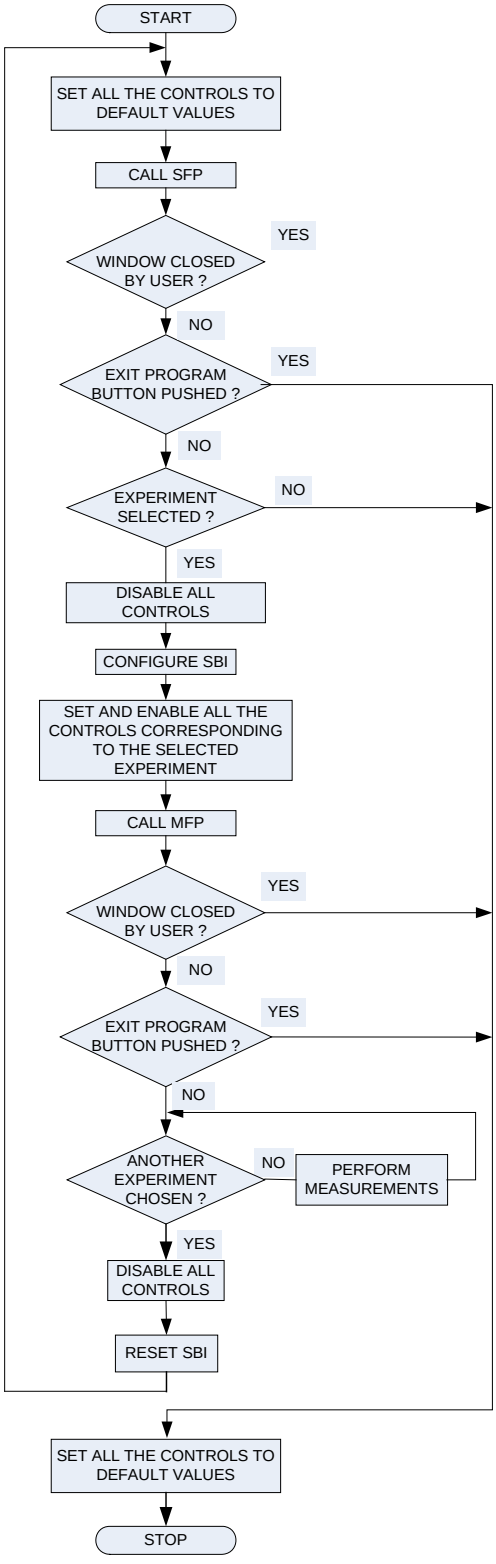

Fig. 3. Flow chart of the main LabVIEW

unsafe for the power circuit. In this situation, as soon as the user is disconnected without exiting the program, the experiment is automatically closed and a warning message is displayed. On the other side, as long as the power circuit configuration is in establishment, no control is available for the user. The same happens when an experiment is finished and another one is selected.

III. THE RESONANT AC CIRCUITS EXPERIMENTS

The Moodle window for booking the experiment is presented in Fig. 4. When the user performs the module, two front panels are handled: one for selecting the desired experiment, called Selection Front Panel (SFP) and the other for visualizing waveforms and measurements, called Measurement Front Panel (MFP). For the moment two types of resonant converters can be examined, namely the *series resonant converter* (SRC) and the *LCC converter* [5], [6]. It is expected to expand the experiments in order to include also the parallel, the LLC and the dual of the series converter. The SFP is presented in Fig. 5 in the situation the SRC converter experiment is selected. Each of the two experiments is assigned its own DAQ Assistant, built according to the signals required to be analyzed in the corresponding rectifier experiment. The signal list, the waveform graph and spectrum analyzer are also converter individualized. Any signal from the signal list can be displayed, inhibited and analyzed separately or together with any other signal. Simultaneous signal display is useful as the phase shift between the signals is always of interest in studying zero voltage or zero curent switching together with semiconductor devices conduction state. Any time the user can stop the acquisition and perform measurements on the displayed waveforms using cursors. Time, amplitude, phase, rms of harmonics, dc and overall rms values and spectrum are available.

The MFP is shown in Fig. 5 for series resonant converter. The switching frequency can be adjusted from the MFP in order to study the behaviour below and above resonance. Attention is focussed mainly on the resonant current and voltages together with rectangular bridge output voltage in order to reveal zero current or zero voltage switching of the bridge transistors and diodes.

Importance is also devoted to the quality factors of the circuits in order to clearly state in what circumstances the sinusoidal approximation leads to valid results. Devices stresses such as peak resonant current in case of series resonant converter and peak resonant current and voltages in case of LCC are also investigated. For the latter converter some other important resonant frequencies, f_m and f_∞ are put in evidence.

The student is first given some theoretical and simulation [7] assignments to solve, followed by experimental work where he or she will be able to verify the theory but also to see how the real components lead to some results that are different from those from theory.

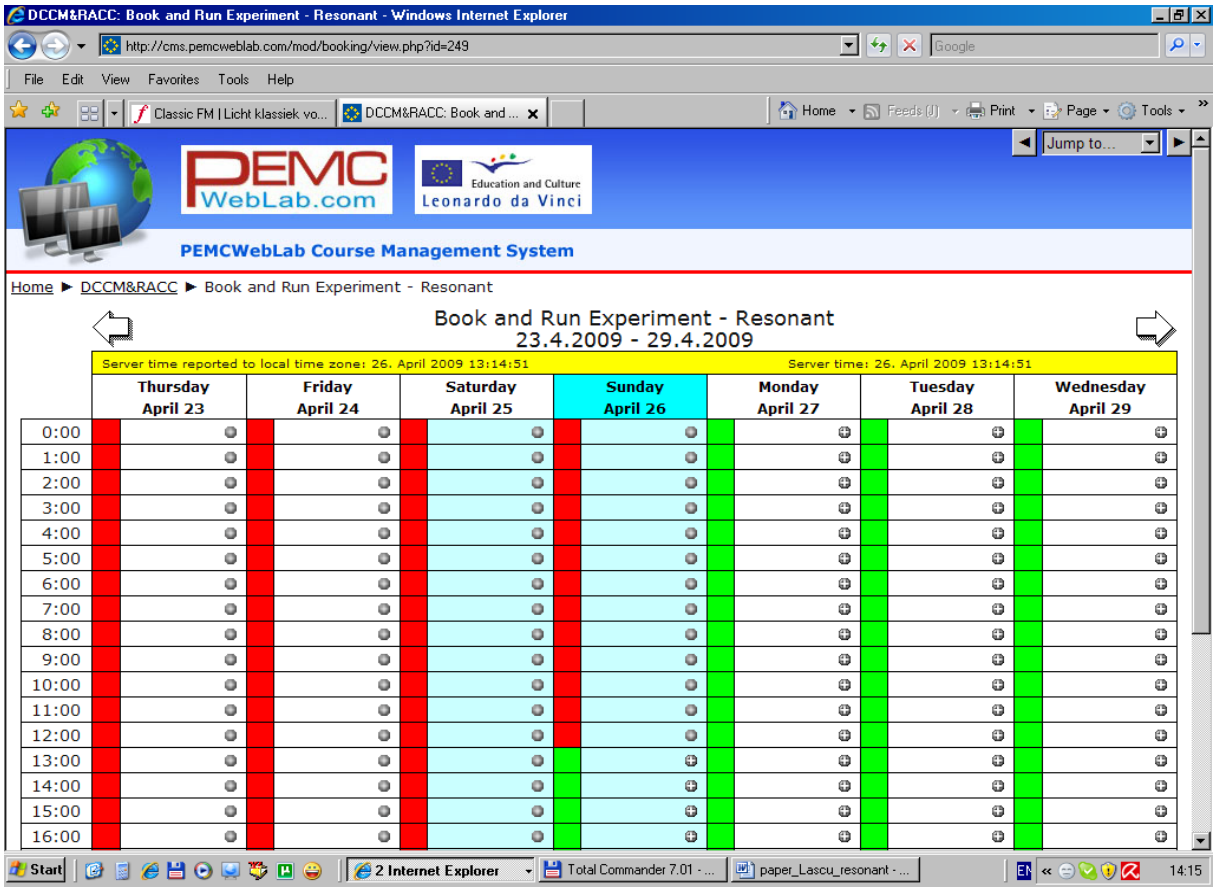

Fig.4 . The booking window.

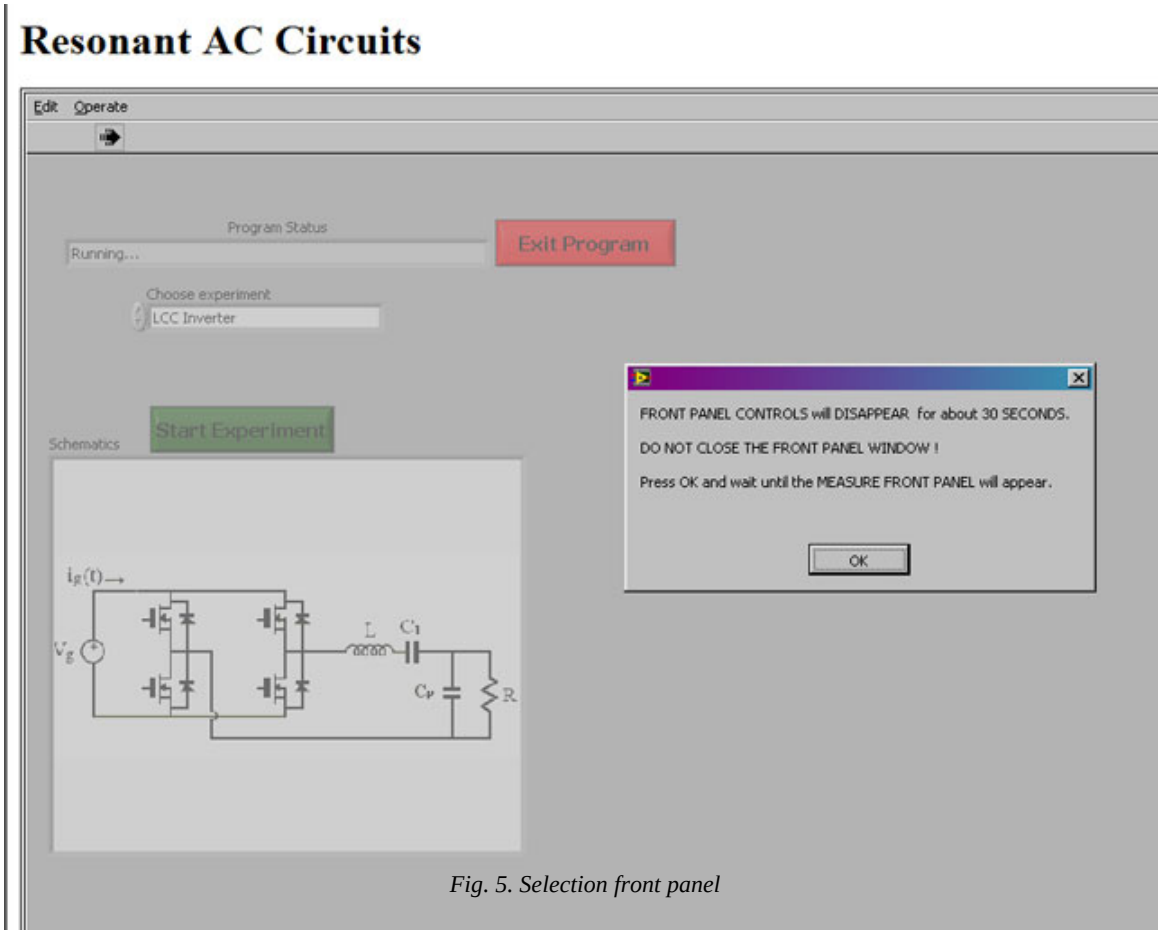

Fig. 5. Selection front panel

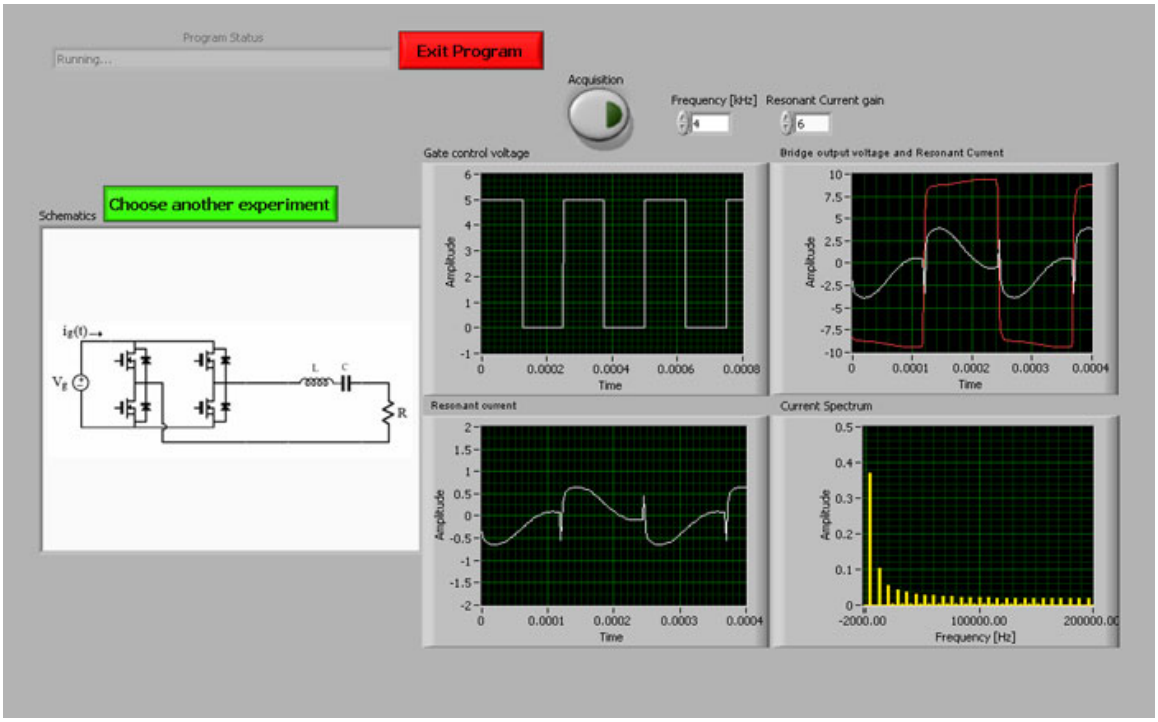

Fig. 6. Measurement front panel (Series resonant converter experiment).

IV. CONCLUSIONS

An E-learning alternative for remote study of basic resonant soft-switching converters is presented. The remote experiments are based on LabVIEW Web Publishing Tools, permanently monitoring the connection in order to protect the experiment. All the measurements that are necessary to understand resonant converter behaviour can be performed. Because they are real experiments, dealing with real waveforms, the student is given the possibility to exploit beyond the simulation aspects and thus to have a real perception of converters operation.

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