Didactical Software Tools on Electrical Circuits and Electrical Machines, Produced in the Frame of the *Leonardo Da Vinci* Pilot Project "Virtual-Electro-Lab"

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Abstract. The presented software tools have been accomplished in the frame of the *Leonardo da Vinci* pilot project "Virtual-Electro-Lab". The aim of the project is developing a complex training system in electrical domain that includes the correlation of the courses, seminars / workshops and testing systems with the virtual & remote experiment elements. It proposes an innovative approach of the teaching method using a virtual & remote laboratory and impies the setting up of new ICT software tools for training in order to implement this innovative approach.

1 Introduction

The presented software tools have been accomplished in the frame of the *Leonardo da Vinci* pilot project "*Virtual-Electro-Lab*". The aim of the project is developing a complex training system in electrical domain that includes the correlation of the courses, seminars / workshops and testing systems with the virtual & remote experiment elements. It proposes an innovative approach of the teaching method using a virtual & remote laboratory and implies the setting up of a set of software tools for training in order to implement this innovative approach. The software-tool set will be used by the teachers that perform didactical activities in electrical domain and it meets a fundamental didactical need: the lack of an intuitive support from practical life that guides the deep understanding.

The software-tool set is divided in three packages:

Package 1, in electrical domain:
1. Properties and characteristics of the materials used in the electrical domain;
2. Simulation and computing of electrical circuits;
3. The electrical transformer and the induction machine;

Package 2, in electronic domain:
4. Measurements of electronic devices and circuits;
5. Measurement & automated test systems;
6. Home appliance systems (DOMOTICS) and peripheral components;

Package 3, in automation domain:
7. Simulation of the electric drives;

8. Designing and simulating of the control systems used in electrical processes;
9. Web-oriented applications on databases used in electrical domain.

Each software tool is enhanced by applications performed in a virtual & remote laboratory.

This paper presents two software tools that belong to the package 1.

2 General description of the software tools

All the software products produced in the frame of the project meet the following requirements:

- Specific interactivity of educational software to obtain a customization of the teaching / learning process.
- Software facilities to organize contents in a systematic and interactive way.
- Individualization of teaching / learning process.
- Demonstration and simulation.
- Remote experiment.
- Continuing evaluation by self-assessment tasks / tests included in the software.
- Peer assessment / inter-evaluation.
- Assessment by tutors via Web.
- Multiple complexity levels.

All the software products have the same structure, which consists of four parts:
1. **The user's guide** explains the user interface, the navigation buttons and other controls and the color code.

Fig. 1. The User's guide.   **Fig. 2.** The course description.

2. **The course description** gives a short presentation in which the objectives, the structure and the target group are presented.
3. **The overview** gives short explanations on each module-course chapter.

12

Fig. 3. The overview.

Fig. 4. Electrical circuits module course content.

4. **The content** allows the access to the module-course content. Each chapter includes the theoretical part and a number of tests that can be solved in sequential way or randomly.

   All products are produced using the dedicated software ToolBook Instructor 8.

3   Electrical circuits module course content

The electrical circuits module course contains a number of seven chapters referring to the linear and non linear circuits, DC and AC circuit and the transient regime. The chapters' objectives are described below:

Chapter 1 BASIC NOTIONS ON DC CIRCUITS

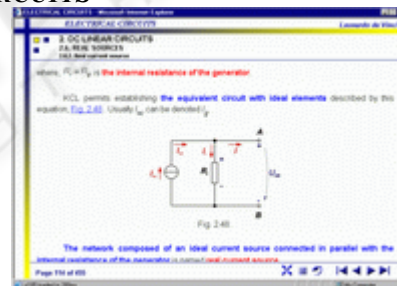**Fig. 5.** Page example from Chapter 1.

Fig. 6. Page example from Chapter 2.

Chapter's objectives: Giving the definition and units for current, voltage and electric power; explaining the Ohm's law and giving the definition and units for resistivity, resistance, conductivity and conductance; explaining the use of the lumped parameter models; explaining the Joule's law and the power dissipation; explaining the electrical charge conservation's law; explaining the working mode of a voltage source with and without load;

Chapter's configuration:

Number of pages: 87, number of figures: 25, number of animations: 8, number of tests: 33, languages: Romanian and English

Chapter 2 DC LINEAR CIRCUITS

Chapter's objectives: Explaining the current-voltage curves for ideal sources and resistors; explaining the Kirchhoff's laws; defining the properties of series and parallel connections; analyzing of a series or a parallel circuit consisting of sources and resistors; calculating the equivalent resistance of a two-terminal network of series and/or parallel resistors; using the voltage- and current-divider relations; explaining the duality principle; explaining the working mode of a real source;

Chapter's configuration:

Number of pages: 81, number of figures: 55, number of animations: 10, number of tests: 31, languages: Romanian and English.
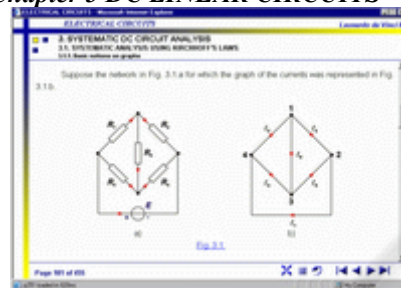
Chapter 3 DC LINEAR CIRCUITS – SYSTEMATIC ANALYSE
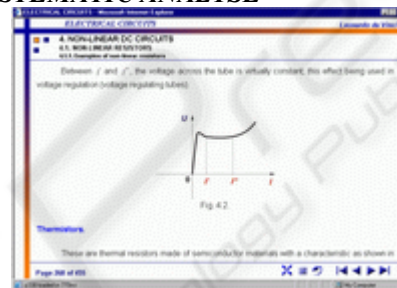

Fig. 7. Page example from Chapter 3.

Fig. 8. Page example from Chapter 4.

Chapter's objectives: Presenting the basic notions on graphs; explaining the applying of the Kirchhoff's laws; presenting the methods for DC circuits analysis; superposition method; mesh analysis method; node analysis method; delta –wye transformation method; presenting the theorems of DC circuits; Thévenin's and Norton's theorems; maximum power transfer theorem; power conservation theorem;

Chapter's configuration:

Number of pages: 87, number of figures: 78, number of animations: 5, number of tests: 29, languages: Romanian and English.

Chapter 4 NON-LINEAR DC CIRCUITS

The chapter explains how: to define and classify the non-linear elements; to define the concept of static resistance; to define the concept of dynamic resistance; to apply the Kirchhoff's laws for non-linear circuits; to solve the case of small slow variations; to solve some particular cases of non-linear circuits

Chapter's configuration:

Number of pages: 36, number of figures: 18, number of tests: 12, languages: Romanian and English.
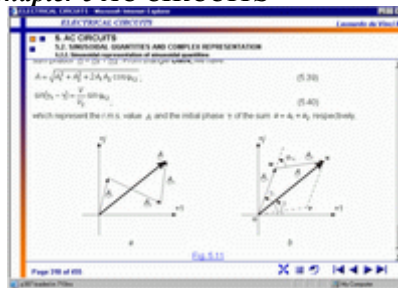
14

Chapter 5 AC CIRCUITS
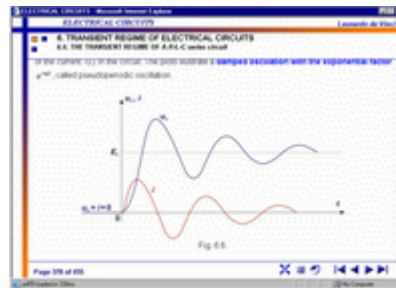

Fig. 9. Page example from Chapter 5.

Fig. 10. Page example from Chapter 6.

Chapter's objectives: characterizing the sinusoidal AC circuit elements; finding out the representation of sinusoidal AC quantities using complex numbers; characterizing the two – terminal circuit using complex quantities; analyzing the operation of passive elements in sinusoidal AC circuits; calculating of sinusoidal AC networks; solving some concrete cases of sinusoidal AC networks;

Chapter's configuration:

Number of pages: 71, number of figures: 18, number of animations: 3, number of tests: 25, languages: Romanian and English.

Chapter 6 TRANSIENT STATE REGIME OF ELECTRICAL CIRCUITS

The chapter explains: how to apply Kirchhoff's laws to electrical circuits; how to establish the initial conditions in order to find the transient state solutions; how to define the steady-state and free components; know the behavior of a *R-L* series circuit when connected to a constant source; know the behavior of a *R-C* series circuit when connected to a constant source; know the behavior of a *R-L-C* series circuit when connected to a constant source

Chapter's configuration:

Number of pages: 39, number of figures: 8, number of tests: 16, languages: Romanian and English.

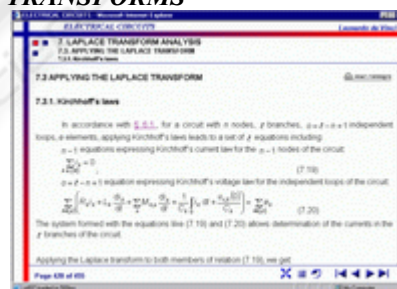***Chapter 7 LAPLACE TRANSFORMS***

Fig. 11. Page example from Chapter 7.

The chapter explains: how to define the operational methods; how to define the original function; how to define the image function (Laplace transform); knowing and applying correspondence of operations through the Laplace transform; knowing and applying the inversion methods; knowing and applying transient state circuit analysis using the Laplace transform

Chapter's configuration:

Number of pages: 44, number of tests: 16, languages: Romanian and English.

Course's configuration:

Number of pages: 455, number of figures: 202, number of animations: 26, number of tests: 162, languages: Romanian and English. Number of titles included in bibliography: 26.

4 Electrical machines module course content

The electrical circuits module course contains a number of four chapters referring to the transformers and the asynchronous motors. The chapters' objectives are described below:

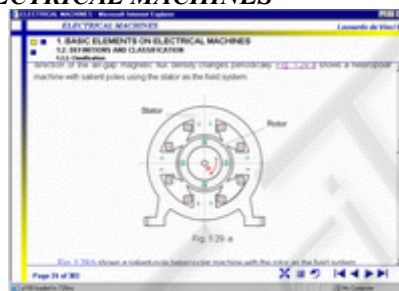*Chapter 1 BASIC ELEMENTS ON STRUCTURE AND OPERATION OF ELECTRICAL MACHINES*

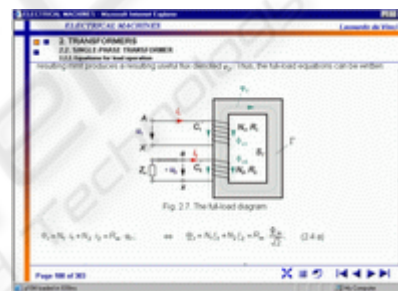**Fig. 12.** Page example from Chapter 1.

Fig. 13. Page example from Chapter 2.

Chapter's objectives: defining and specifying the measuring units of the quantities that characterize the magnetic field; explaining the way in which the magnetic field acts on a conductor that carries an electric current; stating and applying the law of the magnetic circuit in order to explain the operation of electrical machines; stating and applying the law of electromagnetic induction in order to explain the operation of electrical machines; defining the main types of electrical machines; knowing the basic elements regarding the magnetic field in electrical machines as well as the windings of the electrical machines.

Chapter's configuration:

Number of pages: 90, number of figures: 37, number of animations: 16, number of tests: 35, languages: Romanian and English.

Chapter 2 TRANSFORMERS

After studying this chapter the student will be able to: explain the transformer operating mode and the construction elements; know, present and explain the equations for non-load and load operation; know and explain the transformer equivalent circuits; present and explain the experimental determination of the parameters of the equivalent circuit; know and explain the external characteristic; define the powers, loses and the transformer efficiency; know, present and explain some aspects related to the three-phase transformers; know the basic elements regarding some special transformers and understand the parallel operation of transformers.

Chapter's configuration:

Number of pages: 62, number of figures: 27, number of animations: 2, number of tests: 21, languages: Romanian and English.
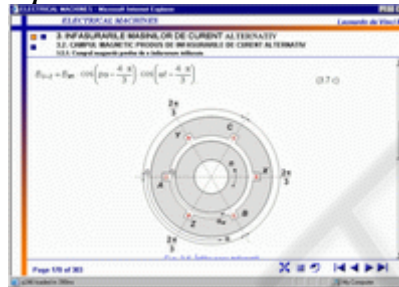
Chapter 3 WINDINGS OF THE A. C. MACHINES

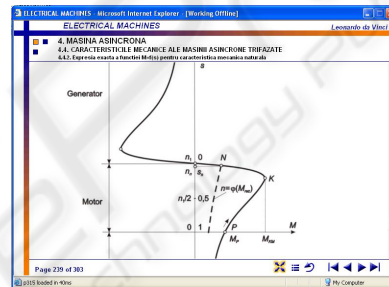**Fig. 14.** Page example from Chapter 3.

Fig. 15. Page example from Chapter 4.

Chapter's objectives: explaining the magnetic field produced by a rotary wheel with poles; explaining and deriving the magnetic field produced by a single-phase winging and by a three-phase winding; deriving the frequency of the magnetic field into a coil of a phase; deriving the value of the electromotive force induced into a phase; deducing the value of the electromotive forces induced into the phases of a three-phase winding.

Chapter's configuration:

Number of pages: 64, number of figures: 9, number of tests: 27, language: Romanian (the English version is in progress).

Chapter 4 ASYNCHRONOUS MACHINES

Chapter's objectives: explaining the principle of the operation of the three-phase asynchronous machines and the main construction parts; knowing and explaining the equations of the operation mode of asynchronous machines and the equivalent circuits; knowing and explaining the energetic aspects of the operation mode of asynchronous machines; presenting and deducing the mechanical characteristics of three-

phase asynchronous machines; presenting and explaining the starting methods of three-phase asynchronous machines; explaining the principle of the operation of the single-phase asynchronous motor and the main construction parts.

Chapter's configuration:

Number of pages: 73, number of figures: 27, number of animations: 3, number of tests: 25, language: Romanian (the English version is in progress).

Course's configuration:

Number of pages: 303, number of figures: 100, number of animations: 21, number of tests: 108, languages: Romanian and English. Number of titles included in bibliography: 16.

5   Impact and perspectives.

The expected impact of the project is high due to its ICTs last generation approach and its innovations in the field of vocational education.

The needs to increase the ICT skills for all Europeans have been pointed out at the European Council in Lisbon in 1999. The project responds to this need by improving the educational methods that use ICT. This spirit of the project will determine the improvement of the skills for all the participants.

Expected impacts in the short term:
- A compatible qualification obtained by the trainees among the partners' countries through the correlation of the curricula.
- Improving the training by:
  - ➢ Increasing the availability of the methods specific to the open & distance learning.
  - ➢ Using the tools generated within the project.
- Reducing the financial effort of the educational units through the access to the virtual & remote experimenting resources of the created system. Exploitation costs of virtual laboratories are low and their periodically upgrade allows a great dynamic evolution and reconfiguration of educational resources with minimal financial efforts.

Expected impacts in the long term:
- Increasing the mobility and adaptability of the labours among the partners' countries by improving the knowledge and skills.
- Modifying the approach of the long term training by sharing and changing the training tools between the partners.
- Facilitating the access to education (tutoring, information and experiment), of a wider range of potential users who want to learn from their school, firm or home, in their free or work time (during re-conversion periods).
- Modifying the decision-taking regarding investment in educational resources, that wouldn't be massive and concentrated in expensive stand-alone configurations, but distributed and flexible facilities and capabilities, with accent on interfacing and communication.