Interactive Learning Tools for Electrical Engineering and Electronics Course

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Introduction

The article reports the results of one of the first attempts to elaborate and implement original student centred interactive learning tools for higher and vocational schools in Latvia. By now Ŕ. Priednieks has developed more than 20 Windows applications in the subject area „Electrical Engineering and Electronics“ (EE&E): laboratory practice simulations, circuit calculation programs, and learning exercises. The learning material presented in CD ROM form includes themes of electrical circuits, electrical machines and basic electronics. Each learning tool contains EXE-file supported by help files with operation instructions, theory, laboratory practice assignment or exercises. The further development of the learning tools was supported by the Leonardo da Vinci Community Vocational Training Action Programme. The learning tools were also translated and now the CD is available in English, Dutch, Estonian, Italian, Latvian, and Lithuanian versions.

I. Electrical circuit learning tools

By 2000 a CD ROM „Electric Circuit Analysis (ELCIRA)” with 13 learning tools has been elaborated and implemented in the higher education system of Latvia. These computer-based learning tools have well-known distance education material advantages, such as: interactive studies in the “computer-student” mode, user-friendly study material, opportunity to choose an individual time and rate of studies, objective evaluating and self-assessment of acquired material, costs of education reduce, etc.

Contents of the CD and a brief characteristic of learning tools see below. Some examples of screen copies with program interface are shown in Fig. 1.

Laboratory practice simulations (L)

All values of electrical quantities, timing diagrams, vector diagrams and function curves are available.

L1. Operating conditions of DC circuit with a variable load resistance.
L2. RLC series connection with variable capacitance C.
L4. Star-connected three-phase circuit with variable 3-phase resistive load in 3- and 4-wire systems, balanced and unbalanced, also in emergency situations.
L5. DC circuit transients. Charging processes of capacitor in RC and RLC circuits with changeable parameters.

We suppose that such specialised simulation programs used for training purposes have some advantages in comparison with universal electrical circuit simulation programs such as:

- specialised programs are released from needless information on the screen,
- they do not require scheming on the screen,
- they are user-friendly, easy-to-acquire,
- each program is provided with specific instructions on use in a help file,
- useful information for training, theory, exercises, tasks is available in linked help-files,
- they are supplied with a graphical part fit for certain study material (vector diagrams, potential diagrams, multi-functional graphics, etc.),
- they are essentially less expensive.

Tests and learning tools (T)

T1. Topology of electric circuits. Interactive demonstration of main concepts of circuit topology.
T2. Labelling of voltages and currents in schematic. Some equations are given; the task is to choose correct reference directions for voltages and currents.
T3. Series and parallel connections: find them in a given circuit. Correction of answers through basic concepts and definitions.
T4. Parameters of sinusoidal current (voltage): phase, amplitude, effective value, frequency, the vector and complex representation.


T6. Active power. Dependence of the product of a sinusoidal current and voltage and its average value (active power) on their phase shift.

Electric circuit calculation programs (C)

C1. DC circuit calculation. Values of currents, potentials, voltages and powers. Some templates for popular circuit configurations given.

C2. Calculation of AC circuits with parallel branches. Plan of calculation, formulae, values of all currents, power and phase shifts. After data varying a schematic and scaled vector diagram appear. Many examples with different circuit configuration and parameters available.

II. Further development

The following learning tools were designed for the Leonardo da Vinci Community Vocational Training Action Programme project (Agreement Nr.2002-LV/02/B/F/PP-138.002). Their screenshots are shown in Fig. 2.

T7. Elements and their series connections (RL, RC, RLC). All parameters and frequency f are changeable. Formulae and electrical values (currents, voltages, active power, reactances, phase shift), timing diagrams for voltages, currents and instantaneous power, and vector diagram for every circuit appear.

Electrical machines (M)

Steady-state operation mode simulation, with control possibilities. Electrical and mechanical values, speed-torque characteristics or voltage-current characteristics accessible.


M4. Separately excited DC generator with variable load resistance and field current.

Basic electronics (E)

Input and output values, timing diagrams accessible.


E2. Logical function synthesis. Logical functions for control of 8 seven-segment LED-displays. A solution process and checking of results is partially automated.

E3. Operational amplifiers. Non-inverting, inverting, and summing operation amplifier circuits may be investigated.

III. Development in perspective

On the way to a distance education course design it is necessary to supply all the main concepts of the “Electrical Engineering and Electronics” with interactive learning materials. Some activities in this direction have been undertaken. Here is a list of programs-in-advance: with algorithms and screen design approximately performed, but yet without any help-file. Some screenshots are shown in Fig. 3.

Some tools for circuit analysis and electrical machines simulation

L6. Thevenin equivalent for a two-source DC circuit.

L7. Delta-connected three-phase circuit with changeable load impedances and phase angles. Values of phase and line currents, vector diagram of currents and voltages.

L8. Active power measurement in three-phase systems with 2 wattmeter method. Values of active power, and indications of wattmeters are shown.

C3. AC circuit calculation. Complex values of currents, potentials, voltages and powers. Some templates for popular circuit configurations are given.

M5. DC motor with series excitation. Laboratory practice simulation


Electronic and microprocessor technique

E4. Controlled single-phase rectifiers. 

E5. Voltage stabilization circuit.

E6. Bipolar transistor characteristics.

E7. Transistor amplifier.


E9. Basic logical functions OR, AND, NOR, NAND.


E12. Karnaugh maps (2x4 and 4x4). Automated logical function synthesis.

E13. Microprocessor 8080 emulator. Program code and data input and modification is possible. In step-by-step mode a content of all microprocessor registers, data area, and stack is accessible.

E14. LED display with microprocessor control. A microprocessor program controls 6 seven-segment LED-indicator display and can be modified.

E15. Arithmetic and logical microprocessor commands.
Fig. 1. Screen copy examples: running programs from CD "ELCIRA"
Fig. 2. Screen copies of running 8 next programs
Fig. 3. Screen copy examples: running programs-in-advance
Conclusions

1. In Riga Technical University a complex of interactive computer-based learning tools for EE&E course is developed. We could not find any analogue in a choice of European training aids.

2. List of learning tools (finished and in-advance ones) with brief characteristics and examples of screen copies are presented in order to give one a taste of their themes, opportunities, as well as interface and a screen design.

3. The set of learning tools must be supplemented with new-elaborated programs in order to cover all main themes of EE&E course.

References

