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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 Ē. 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 breef 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.
L3. Power factor correction. Variable capacitance C in parallel with RL-load.
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.
T5. Addition of sinusoids. Timing diagrams, vector and complex representation of sinusoids.
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 (current, voltages, active power, reactances, phase shift), timing diagrams for voltages, current 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.
M1. Single-phase transformer with variable load reactance and its phase angle.
M2. Three-phase induction motor. Variable values: a load torque, voltage and resistance of rotor circuit.
M3. DC motor with shunt excitement. Variable values: a load torque, voltage and field current. Choice of starting resistance.
M4. Separately excited DC generator with variable load resistance and field current.

Basic electronics (E)

Input and output values, timing diagrams accessible.
E1. Single- and three-phase rectifier circuits with variable resistive load. A smoothing capacitance-filter treated. A current's path for every time interval available.
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 serie excitement. Laboratory practice simulation
M6. Induction motor distance control circuits. Interactive training tool.

Electronic and microprocessor technique

E4. Controlled single-phase rectifiers.
E5. Voltage stabilization circuit.
E6. Bipolar transistor characteristics.
E7. Transistor amplifier.
E8. Schmitt trigger.
E9. Basic logical functions OR, AND, NOR, NAND.
E10. RS-, JK-, D- and T-triggers.
E11. Digital devices. Program for treating a system of digital devices: a counter, register, RAM, ALU and decoder with LED indicator.
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.

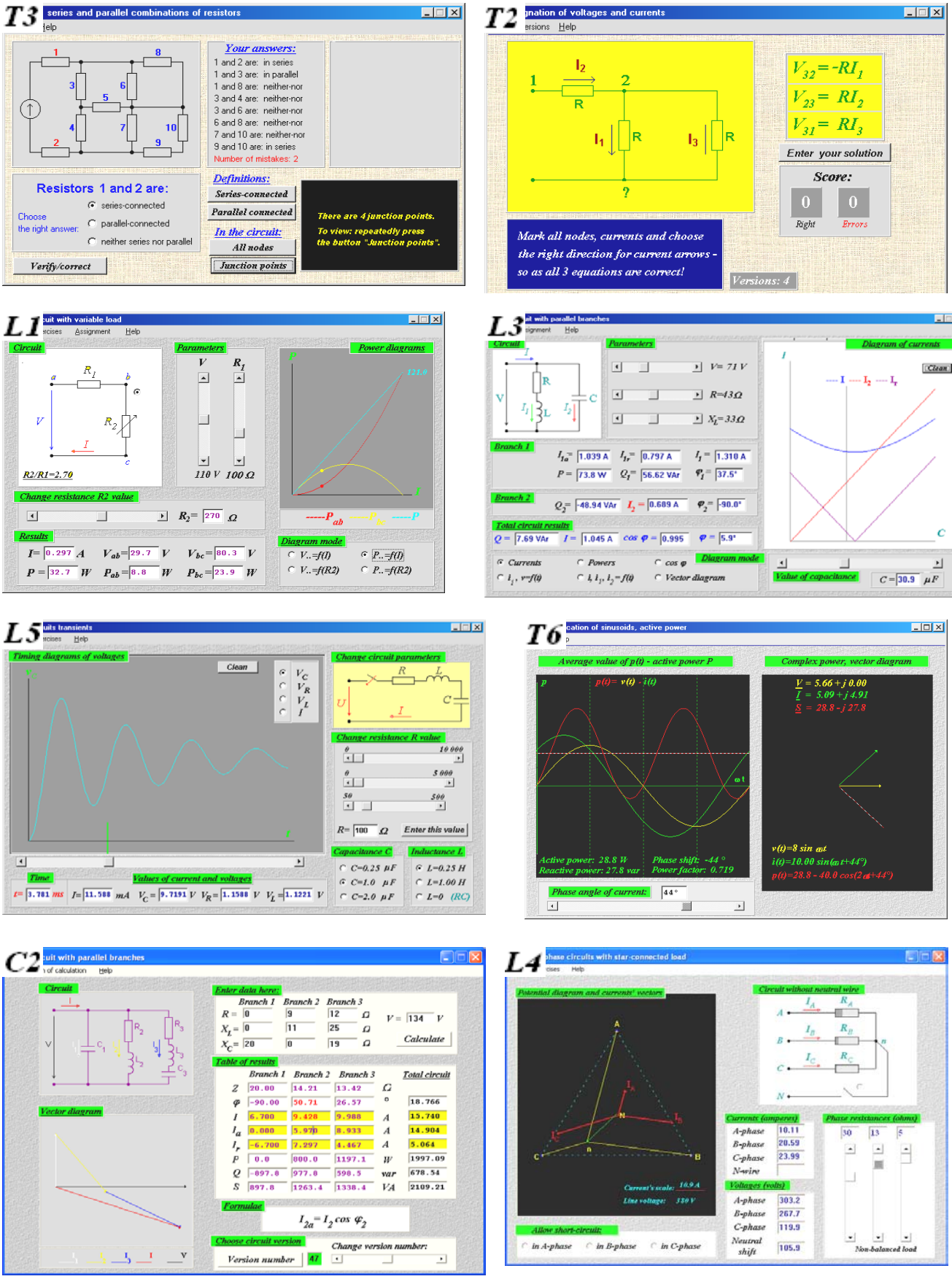

Fig. 1. Screen copy examples: running programs from CD ”ELCIRA”

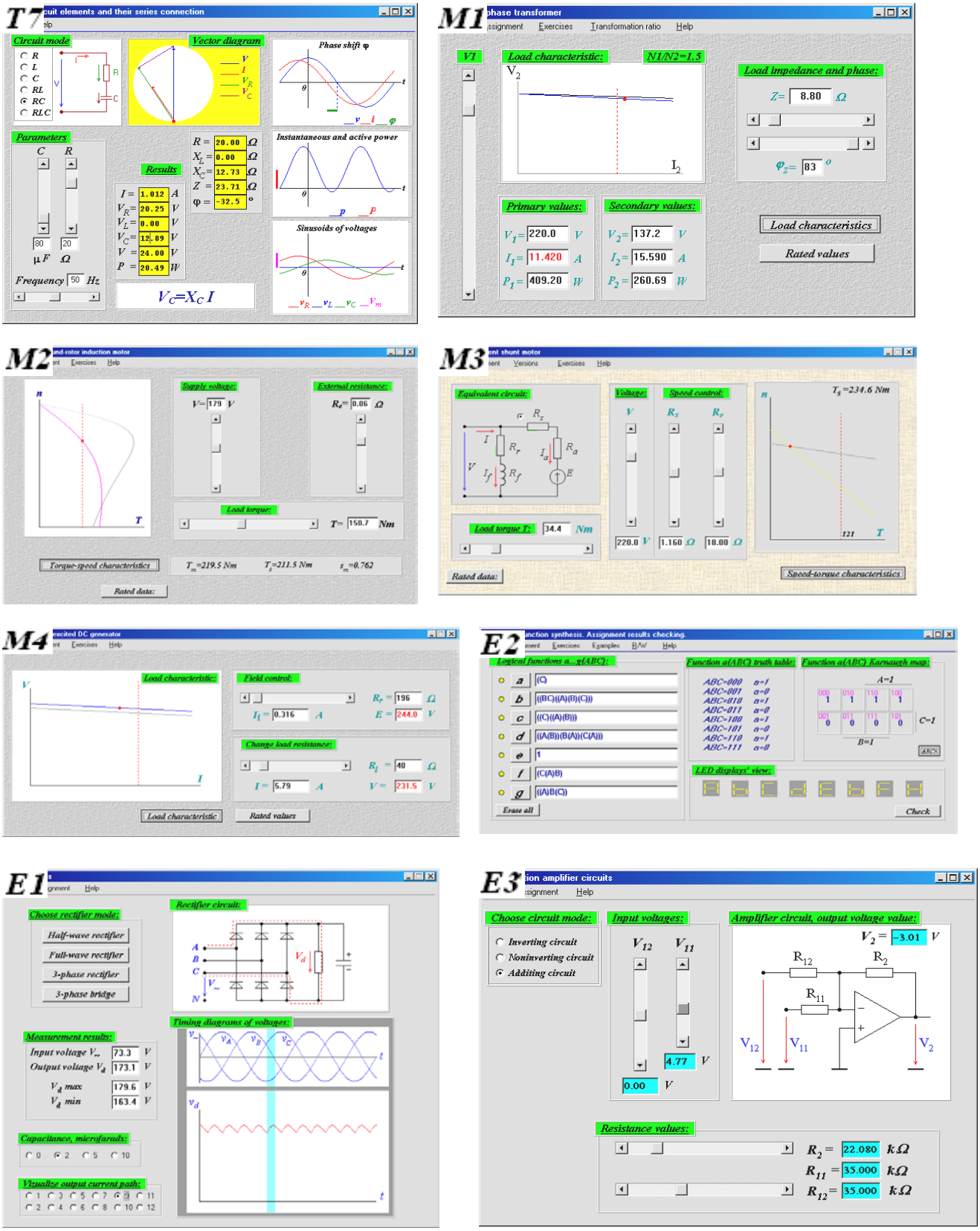

Fig. 2. Screen copies of running 8 next programs

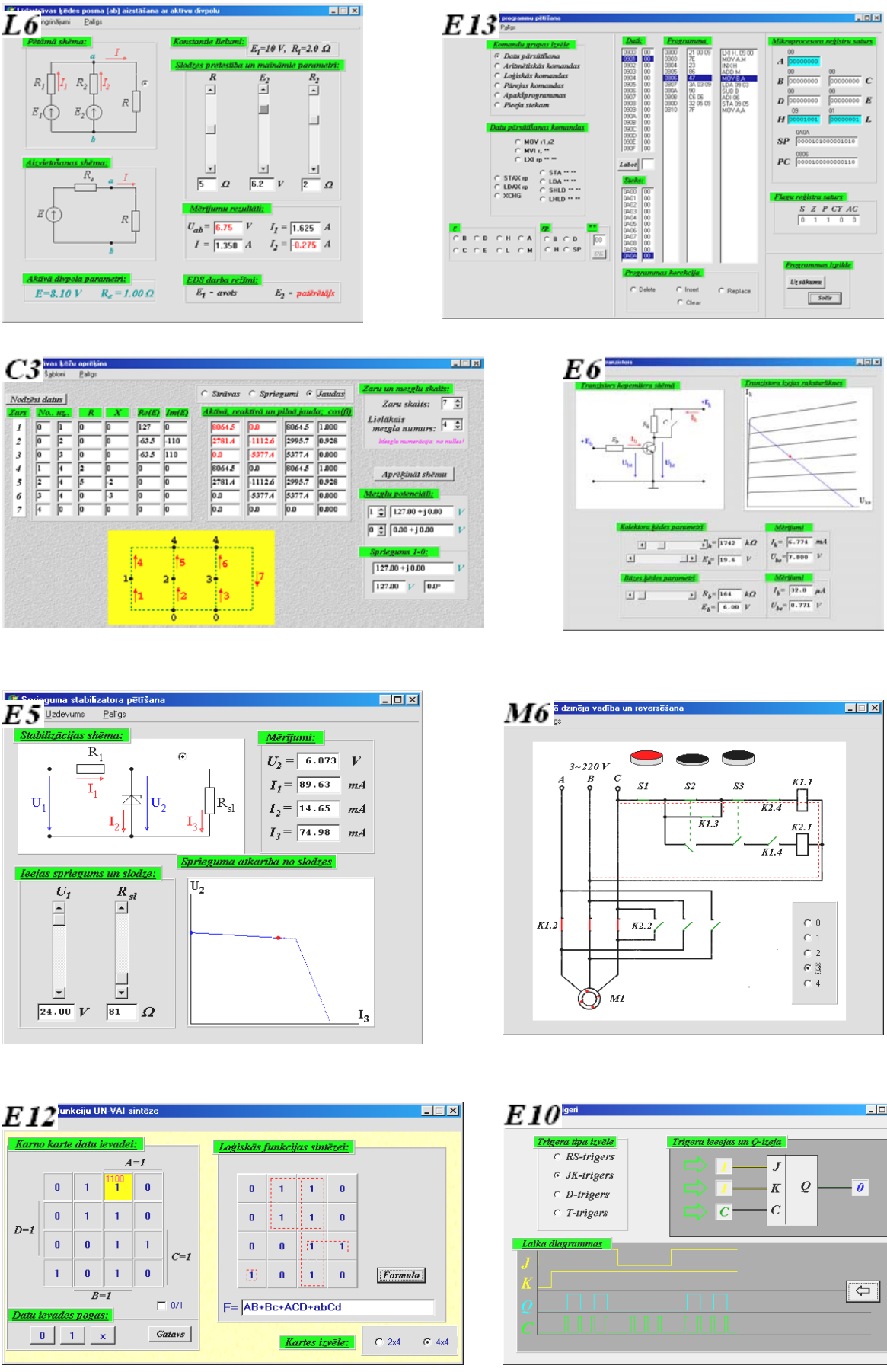

Fig. 3. Screen copy examples: running programs-in-advance

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

1. **Priednieks Ē., Ruplis A.** Student-centred Learning Material in the Engineering Education – CD-ROM „Electric Circuit Analysis (ELCIRA)" // Proceedings of the international conference „Distance Education for Lifelong Learning in 21st Century". – Riga, October 2000. – P. 62–64.
2. **Klēģeris I., Priednieks Ē., Ruplis A.** On the Way to Improving Vocational Education: New Electrical Engineering Study Tool CD ROM Electric Circuit Analysis (ELCIRA) // Research for Rural Development 2002 International scientific conference proceedings, Ed. V. Klāsens a. o., Jelgava, Latvia, 24–24 May, 2002. – P. 99–1.
3. **Antonovičs U., Priednieks Ē., Ruplis A.** Demonstration of Interactive Learning Tools for the Course „Electrical Engineering and Electronics", „Lifelong Learning - a Path to Social Capital", Proceedings of the Conference, Riga, Latvia. – 6–7 November 2003, „Mācību grāmata". – P. 85–91.

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U. Antonovičs, Ē. Priednieks. Interactive Learning Tools for Electrical Engineering and Electronics Course // Electronics and Electrical Engineering. – Kaunas: Technologija, 2006. – No. 7(71). P. 29–34.

The article describes a complex of interactive learning tools (more than 20 computer programs for Windows environment – executable files with suplementary help files) in CD-form for "Electrical Engineering and Electronics" course. The programs were developed in Riga Technical University. Now the CD-ROM is transposed from Latvian language into Dutch, English, Estonian, Italian, and Lithuanian languages. A further development of the program complex is discussed. Figures show screen copies of running programs. Ill. 3, bibl. 3 (in English, summaries in English, Russian, Lithuanian).

У. Антоновичс, Э. Приедниекс. Интерактивные учебные материалы для курса "Электротехника и электроника" // Каунас: Технология, 2006. – № 7(71). – С. 29–34.

Статья знакомит с комплексом интерактивных учебных материалов (компьютерных программ для среды Windows – независимых выполнимых файлов, сопровождаемых рядом файлов помощи) для учебного курса "Электротехника и электроника", представленных в компактдиске. Программы разработаны в Рижском техническом университете. В настоящее время тексты интерфейса и файлов помощи переведены с латышского языка, так что имеются также английская, голландская, итальянская, литовская и эстонская версии диска. Рассматривается направление развития комплекса учебных материалов в перспективе. На рисунках приведены экранные копии работающих программ. Ил. 3, библ. 3 (на английском языке; рефераты на английском, русском и литовском яз.).

U. Antonovičs, Ē. Priednieks. Interaktyvios priemonės elektros inžinerijos ir elektronikos disciplinai studijuoti // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2006. – Nr. 7(71). – P. 29–34.

Straipsnyje aprašomas interaktyvių mokymosi įrankių kompleksas (daugiau nei 20 kompiuterinių programų, veikiančių „Windows" operacinės sistemos aplinkoje – vykdomosios bylos ir papildomos pagalbinės bylos), pateikiamas įrašytas į kompaktinę plokštelę ir skirtas elektros inžinerijos ir elektronikos disciplinai studijuoti. Programos buvo sukurtos Rygos technikos universitete. Šiuo metu grafinės sąsajos tekstai yra išversti iš latvių kalbos į olandų, anglų, estų, italų ir lietuvių kalbas. Aptariamas tolesnis programų komplekso tobulinimas. Paveiksluose pateiktos veikiančių programų grafinių vartotojo sąsajų kopijos. Il. 3, bibl. 3 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).