

THE USE OF PROPRIETARY SIMULATION SOFTWARE IN TEACHING FUNDAMENTALS OF ELECTRICAL ENGINEERING AND ELECTRONICS

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Abstract: The paper presents the possibility of using free firmware to teach the fundamentals of electrical engineering in vocational schools.

Key words: vocational education, firmware, electrical circuit simulation

Lomza State University of Applied Sciences in Lomza includes in its vocational courses in Information Technology and Automation and Robotics classes in the fundamentals of electrical engineering, metrology, electronics and digital measuring systems. In these classes, students learn the basic concepts and laws of electricity and electrical engineering that enable them to solve DC and AC circuits. In turn, the classes of electronics and digital technology discuss the operation of basic analogue and digital circuits. In addition to lectures and discussion classes, laboratory classes are also conducted. The described system of education is in line with the new trends of teaching electronics [1].

My personal observation of the learning process indicates that learning the fundamentals of electrical engineering and electronics involves considerable difficulties for many students. According to information I have received from teachers in direct contact with students the reasons for these difficulties are varied. Most problems arise from the need to link the physical phenomena related to the flow of electric current in the circuit with the mathematical apparatus used to determine its fundamental parameters: current, voltage and substitute resistances. These difficulties are compounded in the case of sinusoidal AC circuits, the solution of which requires the knowledge of complex numbers, as well as in transient states in DC circuits, which require solving simple differential equations. In the case of electronics to solve more complex problems, students should understand how semiconductor components work and how to apply the logical rules of Boolean algebra.

To increase the effectiveness of teaching modern aids are introduced, whose task is, among other things, to make the activities more attractive and to increase student involvement while solving problems. The course in the basics of electrical engineering, electronics and digital technique follows the principle that each lecture should be supported by

practice, during which students solve problems by analytical methods, and laboratory activities, during which practical studies are performed related the content of the lectures. In view of the practical training profile, much attention is given to laboratory activities that require students to independently perform certain tasks and draw conclusions from them.

Typically, laboratory classes consist of the examination of phenomena occurring in a particular electrical circuit. The student should make a theoretical analysis of a circuit and confirm the results by performing a test on a real circuit. The analytical solution of the circuit allows the student to make conclusions about the behaviour of the circuit upon changes in the components used, and, in the case of AC circuits, to determine the frequency characteristics of the circuit.

Especially for circuits with a more complex structure, software that stimulates circuit behaviour is a convenient tool. The theoretical part of the student's task can be done by simulating the operation of the circuit that is the subject of research. Analysis of the results should lead to conclusions that are later confirmed by the results of tests carried out in the laboratory. The market in Poland has a lot of such simulation programs. In general, they can be divided into the following groups:

1. Software created by non-professional programmers – enthusiasts of electronics. These programs have a limited utility, allowing the user to solve only very specific types of tasks. In many cases, the software has been written by teachers or students for a specific course or a specific topic. This type of software uses predefined types of idealised elements, without taking into account the characteristics of real components. The price of such a program is typically very low. Examples of such programs include: **Transformer calculation v0.1** — a small program for

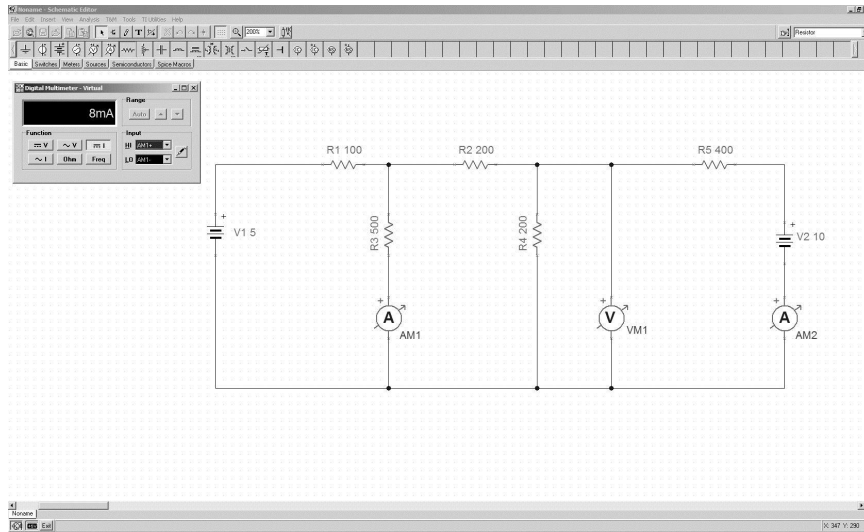


Fig. 1: The Main Window of the TINA Program

calculating numbers of coils and wire thickness, available at www.hw.cz/navrh-obvodu/software/transformer-calculation-vypoctete-si-trafo.html; or **winelekl.zip** – a program for determining the resistance, inductance and capacitance of elements, available at www.elportal.pl/ftp/winelekl.zip.

2. Professional simulation software. The most frequently used simulation software in Poland comes from National Instruments (NI Multisim), Cadence (PSPICE A/D and Advanced Analysis), and Altium (Mixed Signal Simulation, a part of Altium Designer Software). Circuit simulation can also be done using the MATLAB Simulink package with a set of SimElectronics libraries. All of these programs provide comprehensive simulation of analogue circuits of any structure, constructed from components with user-defined properties. These programs are usually included in larger software packages used for the design of electronic circuits and devices – from the wiring diagram to the design of the printed circuit board. In general, the price of professional software is very high – on the order of several thousand dollars in the case of multi-stand versions for universities. Such a price is not acceptable for courses other than Electronics, such as Lomza's Computer Science and Automation and Robotics, where the classes in electrical engineering and electronics do not exceed 120 hours total. Professional software allows the user to simulate the operation of digital circuits with simple structure, built using the basic logical functions included in the most popular families of digital circuits (such as HC, CD4000, LV). The programs used for the simulation of complex digital circuits, which are built using programmable devices, are too complicated for use in introductory classes.

3. Firmware for simulating electrical and electronic circuits. For many years, the leading manufacturers of semiconductor devices offered various kinds of tools that makes

use of these devices easier. The goal of such policies by the companies is clear: to increase the sale of items by facilitating design analysis. The contemporary analogue technology is much different from the historical one, which was based on discrete and relatively simple integrated circuits. The properties of modern analogue components, such as frequency bandwidth, speed and white noise level, do not allow the analysis of circuits using simple analytical methods. In order not to force users to purchase expensive professional simulation packages, companies offer free simulation tools. These can be divided into two basic groups:

1. Programs designed for a specific group of circuits offered by the manufacturer. An example of such software is **LTpowerCAD II** from Linear Technology for the simulation of power supply circuits [2], or the **nanoWatt XLP Battery Life Estimator** from Microchip – a tool to estimate battery life [3].

2. Programs designed to simulate analogue circuits built using elements provided by the manufacturer. In contrast to the first group of programs, any systems may be constructed from both discrete components and integrated circuits by a given manufacturer. The programs offered by two companies: Linear Technology and Texas Instruments are especially interesting. Linear Technology offer his own PSPICE based **LTSpice** software [4]. Texas Instruments offer **TINA-TI** software [5] – free versions of professional simulation software designed by Designsoft. Between the two programs, LTSpice has comparable properties as TINA-TI; however, it is more difficult to use. For this reason, I recommend TINA-TI to students in Computer Science and Automation.

The TINA program is extremely intuitive, and can be mastered in a very short time. The main window of the program is shown in Fig. 1.

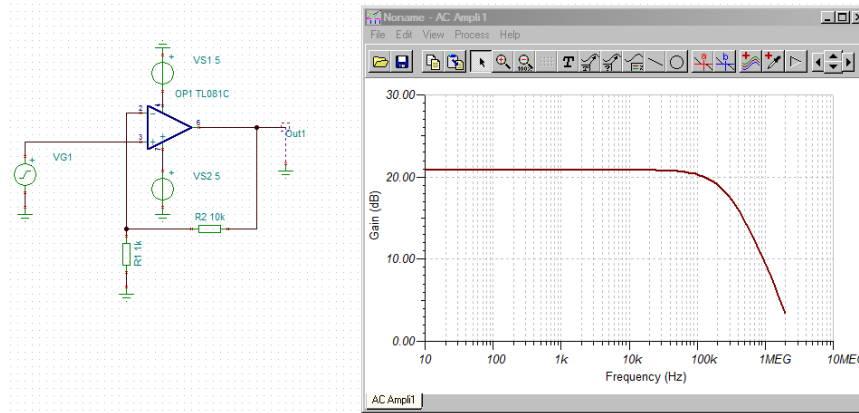


Fig. 2: Noninverting Amplifier Circuit and its Frequency Transfer Characteristic

The user sees a simple circuit editing window. Circuit elements are divided into:

- Basic Elements — e.g. resistors, capacitors, inductors, transformers;
- Switches;
- Measuring Apparatus — ammeters, voltmeters, oscilloscopes, power meters and ohmmeters;
- Sources — voltage sources, current sources, signal generators;
- Semiconductors — diodes, transistors, operational amplifiers;
- Other — A/D converters, comparators, stabilizers.

For electric circuits the user can perform DC or AC analysis. For DC analysis, the user can obtain the amplitudes of currents flowing through branches of the circuit and voltage drops between points in the circuit, as well as determine the transient characteristics of the circuit — the dependence of the output voltage on the input voltage. In the case of AC analysis, the user can obtain rms values of the voltages at different points of the circuits, and the values of the alternating currents flowing through the branches of the circuit. Moreover, a student can obtain the phase difference between current and voltage on every part of the circuit.

For the simulation, the user can also use the simulated measurement apparatus — the readings are made on the on-screen reading panels. This option corresponds to systems implemented in reality in the practical part of the course, where the student uses real ammeters and voltmeters or oscilloscopes.

The program is particularly well-suited for solving problems such as: determining current amplitude and voltage, including in AC circuits; determining substitute resistance, studying transient states in RLC circuits and phenomena of electrical resonance and, therefore, the problems that compose the core of introductory Electrical Engineering courses.

In addition to introductory classes in electrical engineering, TINA-TI software can also be used for classes in basic electronics, which in Lomza have the same overall structure, namely lectures supported by laboratory activities. They can be used e.g. to analyse circuits with semiconductor diodes, transistors or operational amplifiers. For example, Fig. 2 shows noninverting operational amplifier circuit and its frequency transfer characteristic.

The same circuits are practically tested in the laboratory, and the data obtained are compared with the simulation results. The classes of digital measurement systems TINA software is used to design of signal acquisition circuit.

I believe that using proprietary software, such as TINA-TI or LTSpice, to teach the basics of electrical engineering and electronics, is appropriate. Both programs have capabilities comparable to their professional counterparts and are perfectly adequate for a basic level. Their use allows students to validate analytical solutions, and facilitates the understanding of circuits and systems. It also accustoms the students to using modern tools to support design work, which is especially important given the rapid technological progress that we are experiencing in the current times.

Literature

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