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VIRTUAL LEARNING OF ELECTRONICS

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Abstract. *The development of computer technology has enabled the emergence of new teaching opportunities in an artificial, virtual environment. It is then possible to work with electronic systems without the possibility of physical access to them and without measuring equipment. Such teaching and work with electronic systems was possible in a laboratory with computer stations with appropriate software. Only the development of network technology, and in particular the Internet, made it possible to fully virtual work at a distance. Until now, virtual learning has only been an alternative to teaching in a real hardware lab. It was also a supplement to the work that was carried out in the course of practical teaching with students. It was only the emergence of the Covid-19 epidemic that made this type of remote work learning a necessity, but also the only alternative in the event of school closings and quarantines. The necessity of distance learning inspired the use and development of many programs and information systems for this purpose. The paper presents selected programs that can be used and are used to learn electronics at a distance while working remotely. Each of these systems has its own advantages and disadvantages and can meet specific requirements.*
Keywords*: remote work, simulation programs, virtual electronic systems.*

Introduction

The possibility of virtual learning appeared only with the development of computer technology and network technology. Initially, such an option was used in areas of such countries, where people were distant from each other. Pupils or students were separated from the school or university by considerable distances. Difficulties and travel costs were the reasons why a remote form of learning was established. Students and teachers communicated with each other only through devices connected to a computer network. They came to school or university only once every six months or once a year to pass exams. With the advent of the first personal computers in the 1980s, this form of communication could become commonplace. At the beginning, they were quite expensive devices, but with time their price decreased. The popularization of personal computers has also contributed to the popularity of this form of communication. Now it was no longer a necessity, but a possibility to choose this form of work. It also became possible to work in a task force. Pupils or students, thanks to the possibilities of network communication, could work together and exchange information and

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share work (Winiecki, 1997). Virtual work has become a complement to work in a real hardware laboratory. When teaching electronics, students and pupils could check whether the results obtained thanks to simulations in computer programs are similar to those obtained during measurements on real systems, after the classes in the laboratory (Noga, Olszewska, Ptak, Prauzner, & Migo, 2018). The development of remote work is also the development of software needed for this form of activity. There are simulation programs and software packages that are designed to best reflect the work of real electronic systems (Nawrocki, 2002). They can be built and changed as needed, and their operation can be simulated. The results obtained as a result can be compared with the results obtained in a real laboratory.

In this way, virtual work can complement lab work in two ways. It can be a form of earlier preparation for laboratory classes in order to become familiar with electronic systems and their operation (Ptak, 2018b). It can also be a kind of checking the results obtained in the laboratory after classes at school or university. It also makes it possible to carry out tests and measurements of electronic systems that could not be performed in a laboratory (Ptak, 2018a). Whether it's for hardware reasons or because of the limited time spent in the hardware lab. Over time, the verification of the actual results obtained from measurements with the results of simulation and modeling of electronic systems has become a frequently performed procedure (Prauzner, 2016).

Until now, virtual learning was only an option and a complement to classroom teaching in a real laboratory. With the outbreak of the Covid-19 epidemic, this made remote teaching of this kind a necessity. It has also become the only alternative in the event of school closures and quarantines.

Electronics simulation programs

There are a number of software solutions to support work and teaching electronics at various levels of education (Olszewska, Prauzner, Krupa, & Ptak, 2018). Among the various programs that were created, the following programs can be distinguished: NI Multisim, EasyEDA and Autodesk Eagle. Each of these programs has its own characteristics and can be used to perform different tasks. In each of these programs, the same electronic system was built and its operation was compared as well as the advantages and disadvantages of individual software solutions (Dobrowolski, 2014).

The NI Multisim software package enables the creation and simulation of electronic circuits. In this program package, the individual elements of the electronic circuit are represented by appropriate symbols (Swisulski, 2004). By connecting the individual symbols, an electronic circuit is created and the individual connections create paths for the flow of electricity and information (Szabatin, 2003). Both real elements corresponding to the existing electronic elements were built into the program in fact, as well as virtual elements, the

parameters of which can be changed in any way (Winiecki, 2001). There is a version of the Multisim Live program, which is a free version of the program that works in a web browser environment. It allows you to create your own circuitry of electronic components connections and share the created circuits and circuits online. Figure 1 shows the circuit for multiplying a 4-bit number by the number 9 in the NI MultiSim program.

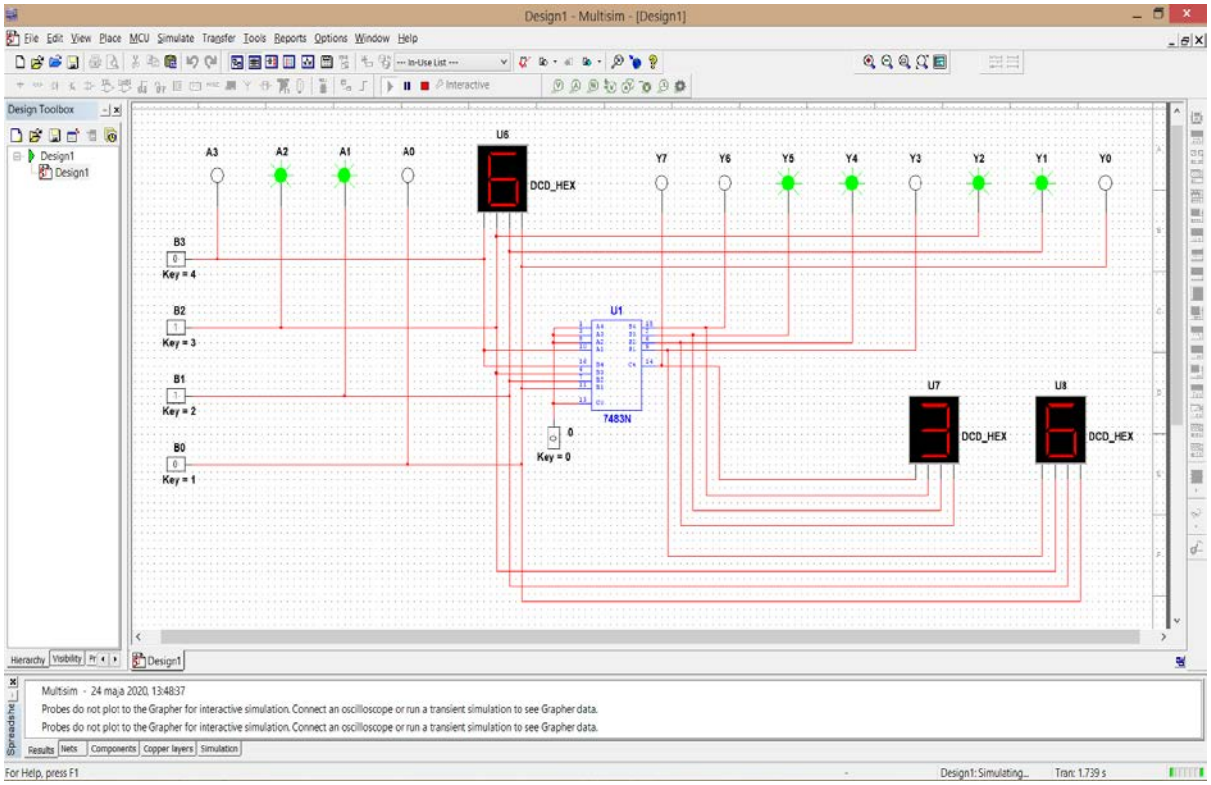

Figure 1 ***Circuit for Multiplying a 4-bit Number by 9 in NI MultiSim*** *(Trajdos, 2020)*

The EasyEDA software package is intended for the development and fabrication of low and medium complexity electronic circuits. This package works online and allows you to import data files from programs such as LTSpice, Autodesk Eagle, Kicad and Altium Designer. Figure 2 shows the system of multiplying the 4-bit number 6 by the number 9 in EasyEDA.

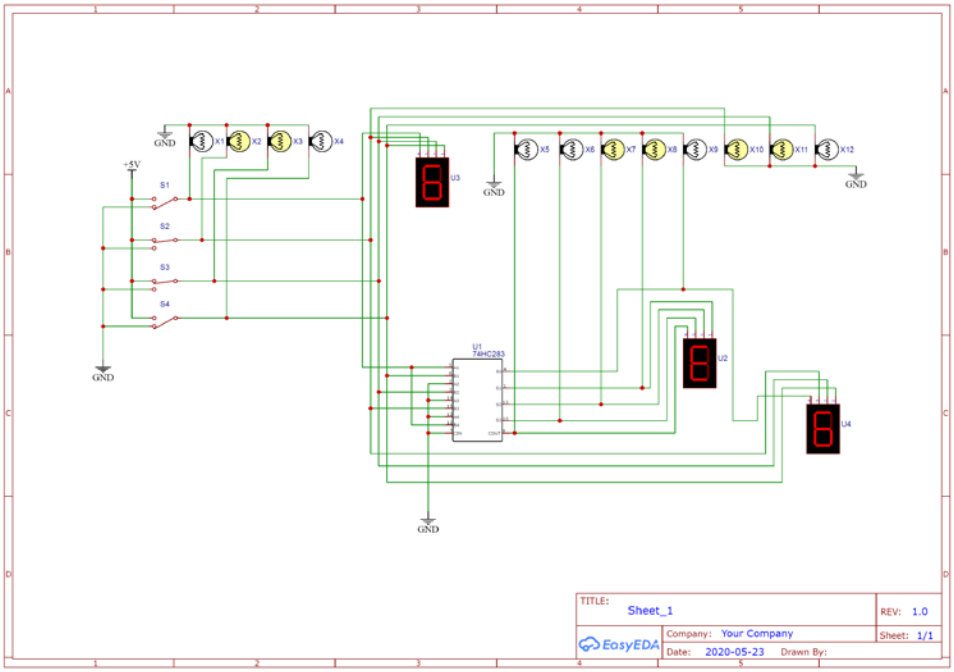

Figure 2 ***A system for multiplying 4-bit 6 by 9 in EasyEDA*** *(Trajdos, 2020)*

In the electronic diagram editor, you can create diagrams using the database existing in the program (Kapica & Scibisz, 2007). It is also possible to create new electronic circuit elements by modification and copying existing elements as well as creating them from scratch (Ptak & Prauzner, 2019).

During the commissioning of the electronic circuit, a variety of analyzes of analog, digital and mixed circuits can be performed. Any errors that arise during the program operation are displayed in text form in a separate program window. The finished simulation results can be exported as CSV files to other software packages. The EasyEDA program is free of charge and has no restrictions on the use of the software. It is also available in the Polish language version and the program itself contains many examples to learn and use in built electronic circuits.

The Autodesk Eagle software suite is primarily intended for electronic circuit design and not for simulation. It includes a schematic and PCB editor. The advantages of the software include simple operation and the possibility of using one version of the software for free, but only in the version for non-commercial applications. It can perform only two circuits of electronic circuits and two signal layers on a printed circuit board at the same time. In figures 2, 3 and 4 shows a layout designed from ready-made SPICE models that are shared in the program as examples. The constructed circuit does not reflect the real system of multiplying a 4-bit number by the number 9, but only imitates its operation. The model of the electronic circuit made consists of three models connected in a cascade. The first is a one-bit adder circuit, the second is a four-bit adder circuit, and the third is the multiplication circuit by 9.

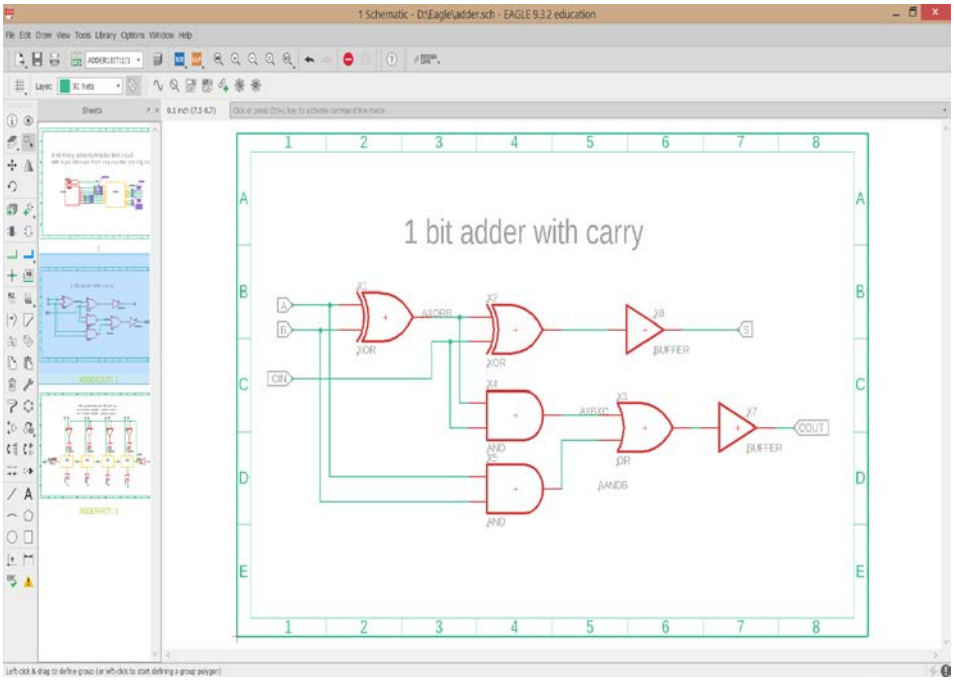

Figure 3 ***Single-bit adder circuit in Autodesk Eagle*** *(Trajdos, 2020)*

Based on the simulations performed, the following conclusions can be made. The best simulation program with the most possibilities is NI Multisim (Prauzner, 2017). Taking into account the correctness of the simulation performed in the NI Multisim and EasyEDA programs, the obtained simulation results agree with the results obtained in real measurements of electronic circuits (Jedrzejczyk, 2017).

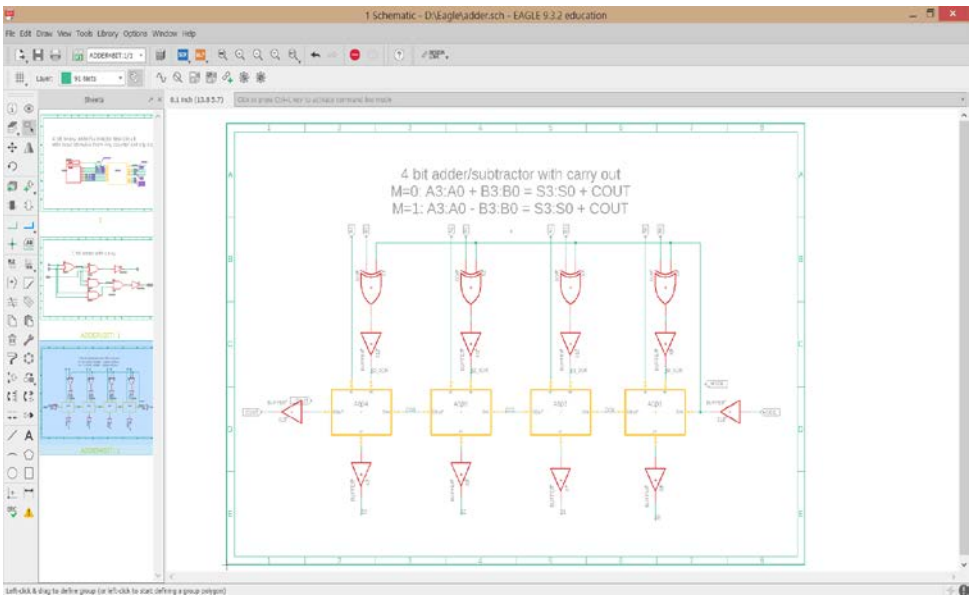

Figure 4 ***Four-bit adder circuit in Autodesk Eagle*** *(Trajdos, 2020)*

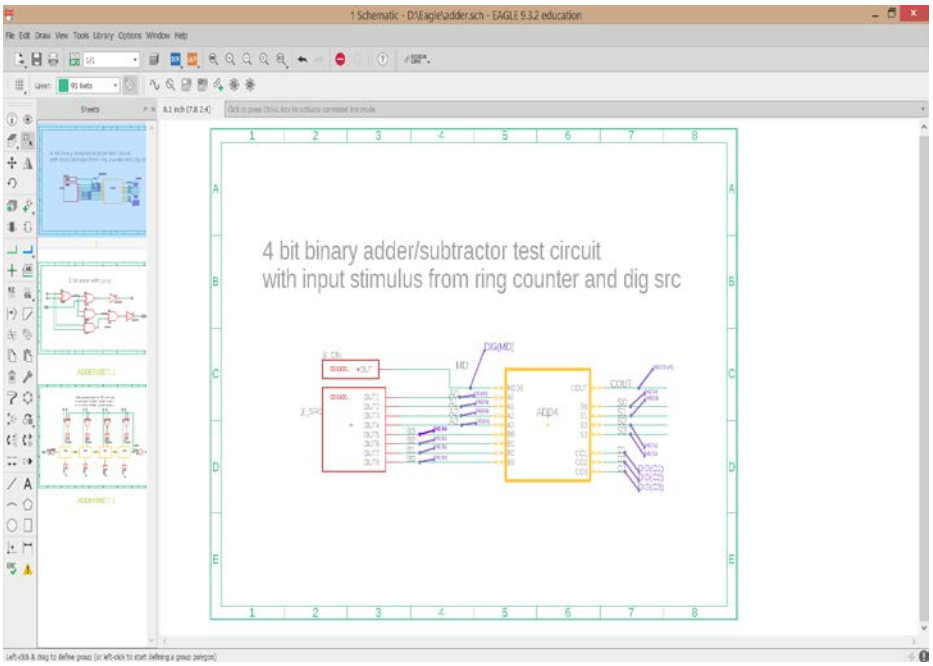

Figure 5 ***Multiply by 9 in Autodesk Eagle*** *(Trajdos, 2020)*

The worst simulation was made in Autodesk Eagle. Additionally, during the simulation in this program, erroneous jumps appeared on the logic diagrams. In terms of ease of use, the program EasyEDA has the most user-friendly interface. The NI Multisim and EasyEDA software packages have extensive libraries of examples and components that can be used to build your own electronic circuits. The worst program is still Autodesk Eagle, in which to perform simulations you have to create element models yourself, which is time-consuming and not easy. It is intended in principle only for low complexity electronic circuits and difficulties.

Conclusions

The possible use of the presented programs for distance learning electronics depends on what we intend to achieve. Each of these programs has different capabilities, and their operation may be easy or more or less problematic. An important factor is also the availability of software in Polish in the case of the EasyEDA program. If we do not have the financial resources to purchase a license for the NI Multisim program, which is the most expensive but has the greatest possibilities, the free versions of EasyEDA and Autodesk Eagle programs can be used. Considering the possibilities, the best program is NI Multisim, but it is the most expensive and does not have a Polish language version. Taking into account the Polish user interface and the free version, EasyEDA is the best program. Autodesk Eagle software is the most problematic software on this list, and the free version has serious limitations. It also does not have a Polish language version.

The use of individual programs depends on the tasks that we intend to achieve (Winiecki, 2014). It is the electronics teacher who decides how these programs will be used in distance learning during the Covid-19 epidemic and as support software for stationary work. In the case of working in quarantine or remote work, the problem remains to verify the data received in simulation programs. Since we do not have access to data from real electronic systems in this case, it can only be assumed that the data obtained as a result of the simulation are correct and largely identical to the real data.

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