Web-Based Circuit Animator to Aid in Teaching Circuit Theory

Hisham Alnajjar & Louis Godbout
Electrical & Computer Engineering Department
College of Engineering
University of Hartford
alnajjar@hartford.edu

Abstract
As we all know, motivating students to work on certain subjects in their major is sometimes a tough thing to do. It can get even harder when trying to motivate students in one major to work on a subject they have to take in another major. When Civil, Mechanical and other non-electrical engineering students enroll in a required introductory Electrical Circuits course, it is sometimes impossible to encourage the majority of them to take the course seriously. They, as we all know, have the attitude that it is not in their major and a C or a D grade is sufficient.

Based on our experience in teaching this subject to non-major students over many years, a web-based circuit animation file was developed for students to use as a supplement to the course. The circuit animations cover all of the basics in direct current (DC) circuit theory. Through the animations, the theoretical and practical aspects of basic DC circuit principles are presented. The topics considered are: Ohm's law; series and parallel resistor combinations; Kirchhoff's laws; voltage and current dividers; nodal, mesh, and loop analysis; Thevenin's and Norton's theorems; superposition; and first-order RL and RC circuits. This paper will explain this project and its usefulness in teaching Introductory Circuits for non-majors. Of course, the animation files are also extremely useful for the education of Electrical Engineering majors as well.

Introduction and Discussion

As stated earlier, teaching circuit theory to non-electrical students can be very challenging. A good percentage of these students think that a passing grade is all they need because the subject is outside their discipline. Many are also "turned-off" to Electrical Circuits because they feel the material is too abstract, thus making the course unexciting. It is a fact that this new generation of students is very much computer and web oriented. Furthermore, a significant number of these students have played computer games while growing up and are used to animated information. So, how about playing their game? We felt by introducing web-based circuit animations to aid in teaching a circuit theory course, we might be able to get them involved and motivated.

The web-based circuit animations were developed for students to use as a supplement to the course. The primary goal is to introduce all engineering students to the elementary principles of DC circuits. Using animated graphics, DC circuit fundamental laws, analysis techniques, theorems, and examples are presented to enhance student understanding of these concepts. It is designed to show students step-by-step how a circuit is approached and solved for the desired results. It shows via animated pictures how resistors in series or parallel can be combined, how

voltage drops are summed around a circuit loop, how currents are summed leaving a circuit node, etc.

All animations are done in a very easy to understand sequence with various colors, large fonts, clear drawings and sketches, and explanations for effortless viewing. Animation speeds tend to slow so that students can keep up with the material being presented. Of course, the instructor can adjust the speed (faster or slower) of any animation dependent on the needs of the students in his/her class. An added advantage is that students could create their own circuit animations to exhibit their understanding of a particular circuit concept. Another advantage is that the animator is available at any time from anywhere with an Internet connection. Thus, the animator works as a full-time virtual professor. With these benefits, we hope that circuit theory concepts will become easier for students to understand which will, in turn, help improve their performance in this subject.

The Circuit Animator starts by giving students the option of selecting a subject to be reviewed from a menu. When a student chooses a topic, a link will take him/her to that section of the course. He/she will have the options of reviewing the theory or going through examples. If the theory is chosen, a clear explanation will be displayed for the student to review. However, if an example is chosen, the student is led through comprehensive steps of explanations and animations to show how the theory is applied to achieve a certain desired result. The student may play back the animation as many times as needed and could stop at any time to think about the theory and the explanation. After that, the student may choose to review another problem on the same topic or simply switch to another topic and see more explanations and examples. The student then could choose to test his/her own knowledge and skills in that subject by choosing an example, find the answer on his/her own, and then check it on-line.

<u>An Example</u>

An example is presented below to show how students will encounter the animations and how this can be effectively used for understanding the concepts. The example is on loop analysis. When a student selects loop analysis, he/she may then choose to look at loop analysis theory or a loop example. If the example component is chosen, the example circuit is displayed and the resultant response is asked for as shown in Figure 1 below. Consider the 4-quadrant network. Find I_0 using loop analysis.

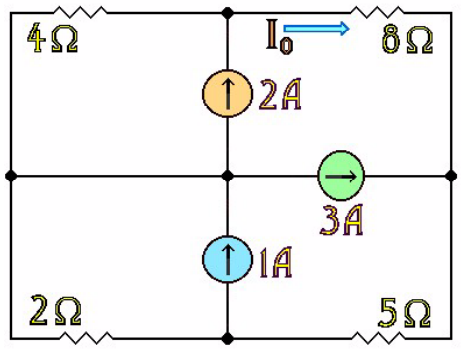
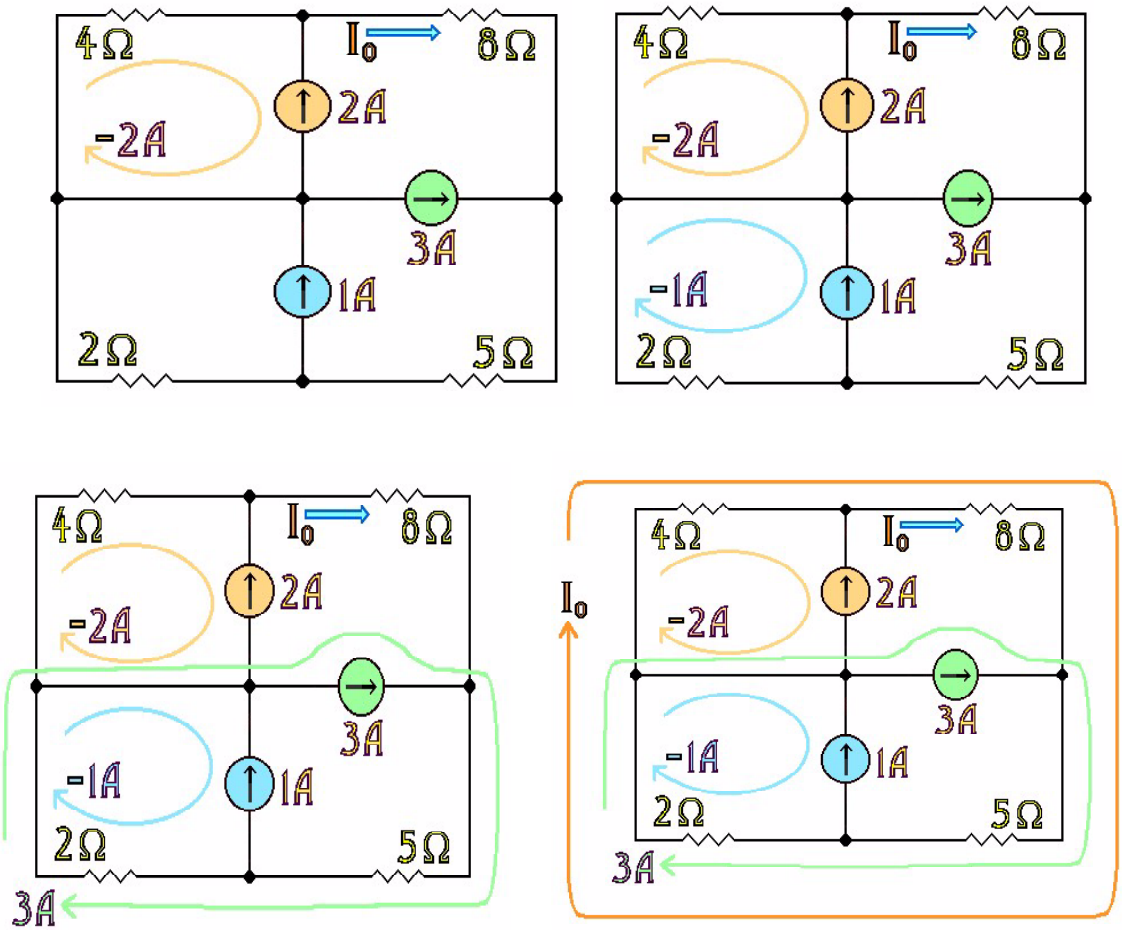


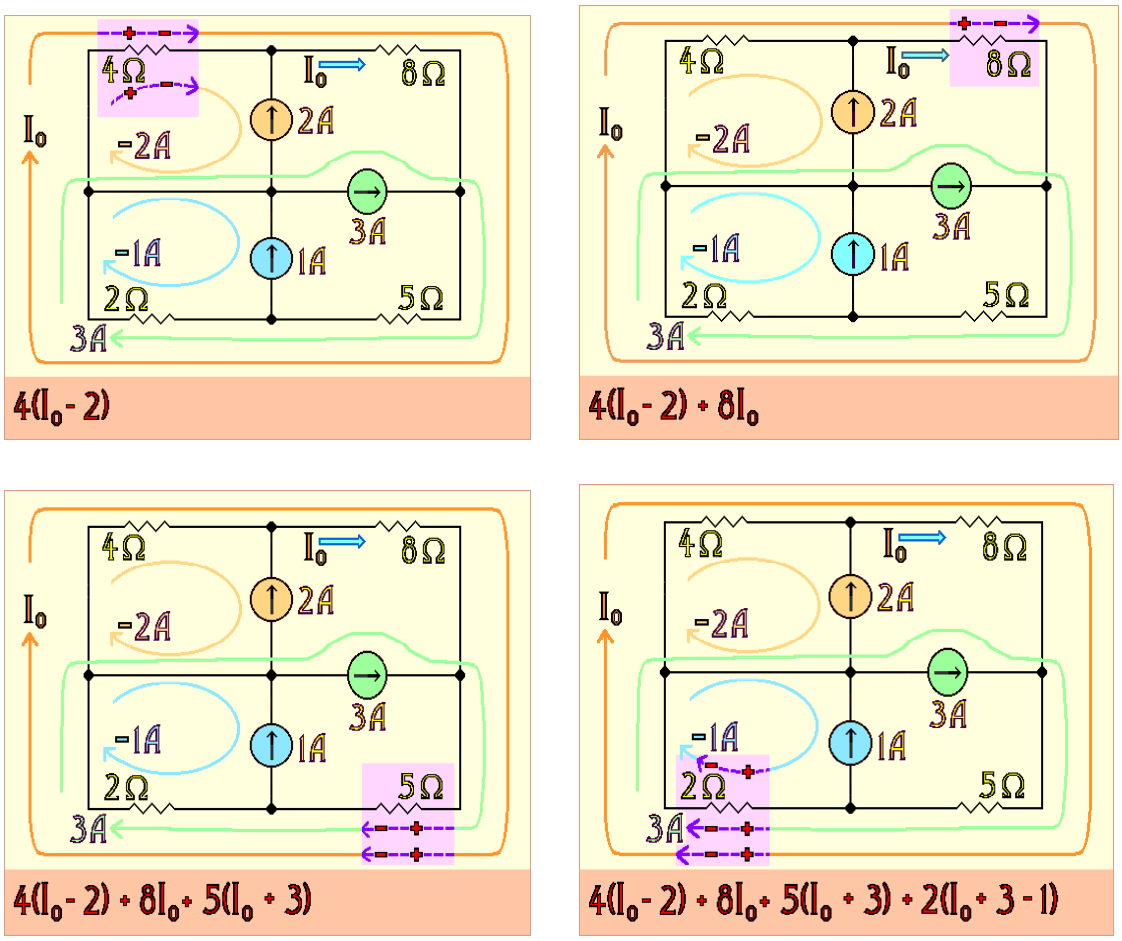
Figure 1: A Four-Quadrant Network

In the next animation the loops are defined and displayed as shown in Figures 2.



Figures 2: Loop Definitions

At this point the loop I_0 is flashing and the student is invited to click on it in order to determine this unknown loop current. When the student clicks on I_0, he/she is reminded with a statement of the theory (Satisfy Kirchhoff's Voltage Law around that the I_0 loop: i.e. the algebraic sum of the voltage drops around that loop is ZERO). The animation then proceeds to generate the KVL equation around the loop as depicted in Figures 3.



Figures 3: KVL equation around the loop

The loop equation that is generated is (Figure 4):

$$4(I_o - 2) + 8I_o + 5(I_o + 3) + 2(I_o + 3 - 1) = 0$$

OR

$$19I_o = -11$$

Figure 4: The Loop Equation

The final result of I_0 = -0.579A will then be given.

Conclusions

A Web-Based Circuit Animator was presented. The animator was developed to visually aid students in understanding and applying the concepts of circuit theory, and it covers all of the

basics in DC circuit theory. We have used this tool in an introductory course for non-majors and have noticed an improvement in students' performance due to better understanding of circuit setup and mechanism. By being able to see how current flows through a circuit, or how a voltage is looked at between points or how circuit elements are merged (in series or in parallel) to find an equivalent circuit, techniques become easy to follow and imitate. Also, since the theory is a click away, students were eager to check it out again and again to review and compare the process and that enforces the learning process.

The animator can be used in several ways; one can use it as a supplement to a textbook where students can check it out on their own, or one can use it in class to show students examples and enforce the concepts, or it can be used as a combination of the above. We have used it in both ways and more and more we are using it in class. For the future, we intend on asking students to produce animated examples to add them to the current examples for future students.

Students have indicated that they enjoy using the animator to help them correlate between DC circuit theory and examples. Many students think the animator should be extended to include alternating current (AC) circuits. Still others think that the addition of sound to the animation will further enhance the learning of the concepts. All of this leads us to the realization that computer-oriented students are not only ready but eager to learn using the techniques presented in this paper. The following link will show a demo of this system
http://uhacoent_1/Godbout/dcckts/mainindex.html

References

- http://uhacoent_1/Godbout/dcckts/mainindex.html
- Animagic software

Biography

HISHAM ALNAJJAR
Chairman, Associate Professor of Electrical & Computer Engineering & Assistant Dean, College of Engineering. B.S.E.E., Aleppo U., Syria; Diploma in Power Systems, Damascus U., Syria; M.S.E.E., Ohio U.; Ph.D., Vanderbilt U. Major Interests: active noise control, fault monitoring of power transformers, target detection & estimation, and speech recognition.

LOUIS GODBOUT
Professor of Electrical & Computer Engineering. B.S.E.E., M.S.E.E., Ph.D., University of Connecticut. Major interests: Digital Control Systems, Multirate Systems, Visual Simulation, Mechatronics, and Digital Signal Processing.