CircuitLab: An (almost) Free Online Analysis and Simulation Tool

Dr. Thomas Ricard
Saint Leo University

Abstract

An inexpensive, web-based analysis tool to supplement an electric circuit analysis class is presented. The use of simulation software in a beginning analysis course is recommended in order to allow the student to verify analysis techniques and as an introduction to computer aided modeling and analysis techniques. CircuitLab is a web-based simulator that requires no download or installation, utilizes an intuitive build/simulate methodology, offers a generous array of capabilities in a free version, is inexpensive to upgrade, and has been implemented successfully in circuit analysis classes at Saint Leo University. The platform functions with a wide variety of web browsers and provides students with a working introduction to a necessary part of engineering design.

Keywords

Circuit Analysis, Circuit Simulation

Introduction

The main campus of Saint Leo University is located in Saint Leo, Pasco County, Florida, about 35 miles northeast of Tampa. Approximately 2400 students are in residence at this primarily liberal arts institution. In recent years, Saint Leo has maintained a small engineering program that offers a minor upon completion. The program draws its participants primarily from majors such as biology and mathematics. Class sizes are small, typically averaging 10 students or less. Budget constraints are based on the relatively low level of participation.

The implementation of a web-based platform called CircuitLab[1] to allow students to perform functions such as schematic capture and circuit simulation as part of the Circuit Analysis course is described. Since the functionality is web-based there is no software or licensing to purchase, no cost to the school and minimal to no cost to the student. Additionally, the use of web-based software ensures compatability across diverse hardware platforms. This is viewed as a major advantage over locally installed free packages such as ORCAD Capture[2]. While several online analysis platforms are available such as Circuit Cloud[3], Easy EDA[3], Gnucap[5] and others [6-8], CircuitLab was chosen for its intuitive design and operation, wide range of capabilities and compatibility with numerous web browsers and operating systems.

An account must be established on the CircuitLab website before any simulation can be performed. A basic account is free, and allows the student to build and simulate any circuit. Basic information is required, such as name, email, and the user's choice of password. It is recommended that the students use their institutional email rather than personal address; this will

help to justify the student rate if an expanded account is desirable. Circuits may not be stored or printed using a free account, although it is possible to "cut-and-paste" designs into other software packages. Any circuit transferred in this way is nonfunctional. A student account allows the user to save and print designs. This feature is especially useful if previous designs are expanded upon in later assignments. Instructors are given free access to these capabilities; for students, the cost is around $12.

Building Circuits

CircuitLab has two modes of functionality: Build Mode and Simulation Mode. Any new design opens automatically in Build Mode. The initial Build Mode screen is similar to a graphed engineering sketchpad, as shown in Figure 1.
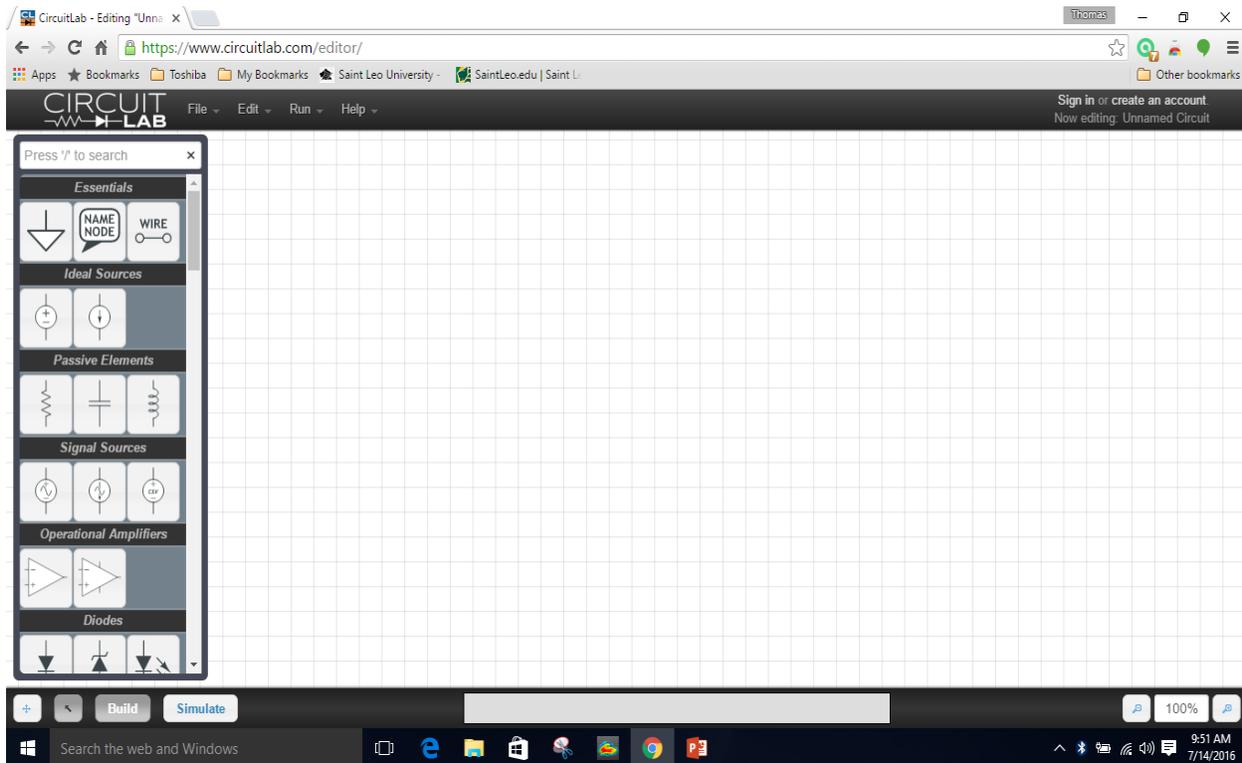

Figure 1 – CircuitLab Initial Design Screen.

Circuit construction is accomplished by "clicking-and-dragging" the desired component from the selection bar at the left of the screen. All circuits must contain a ground point, and wires may be drawn to connect the components. Figure 2 shows a grounded DC power supply with connecting wires attached. The shaded resistor on the right of the circuit is being dragged into position to be connected across the power supply.
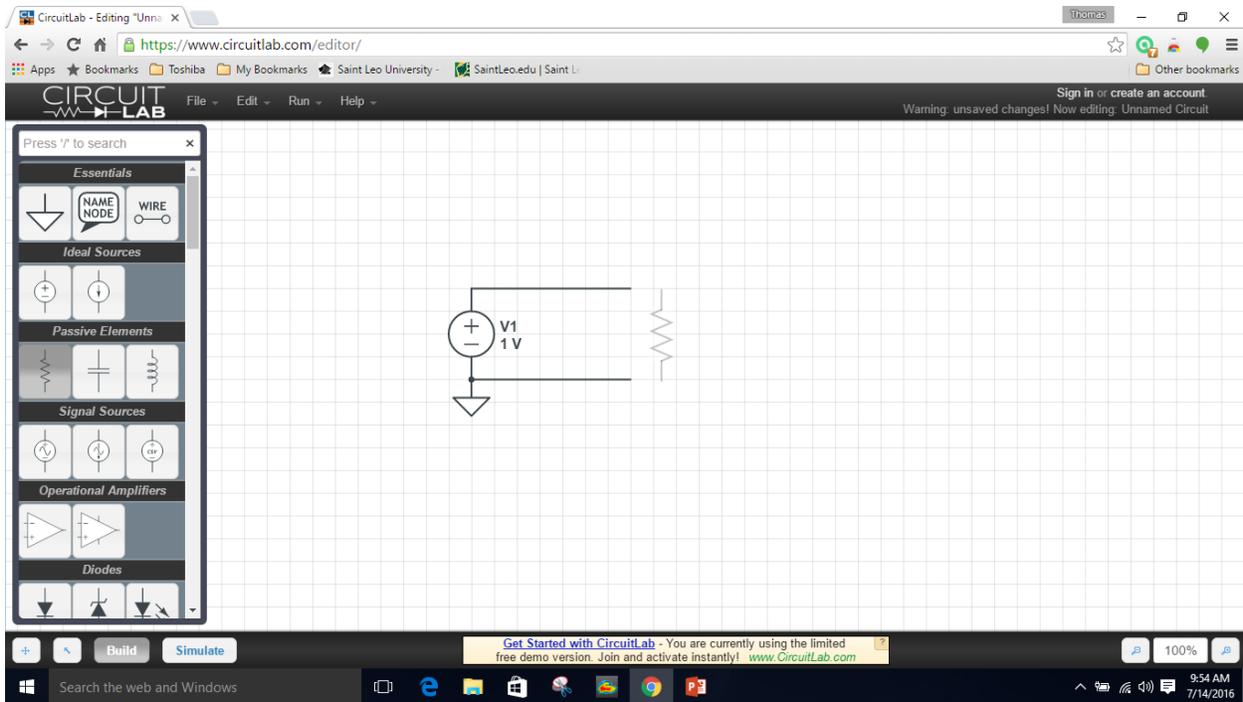
Figure 2 – A DC Power Supply with Ground and Connecting Wires

Parameters for all circuit components may be customized by right-clicking on the device. This action opens a dialog box that allows that allows the user to rename a device, set values, and choose from models of existing designs. The resistor dialog box is shown in Figure 3.
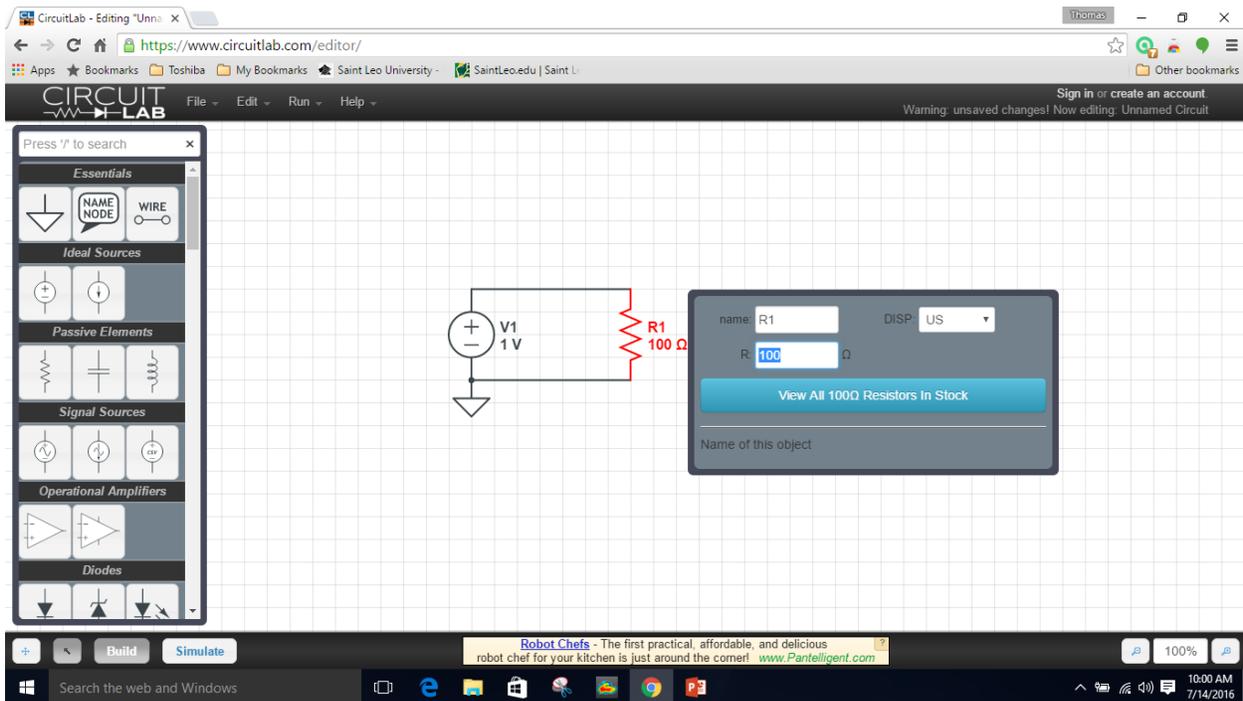

Figure 3 – Component Customization Dialog Box

A simple voltage divider circuit is illustrated in Figure 4. In this example, two nodes have been identified to provide voltage indications in Simulation Mode.
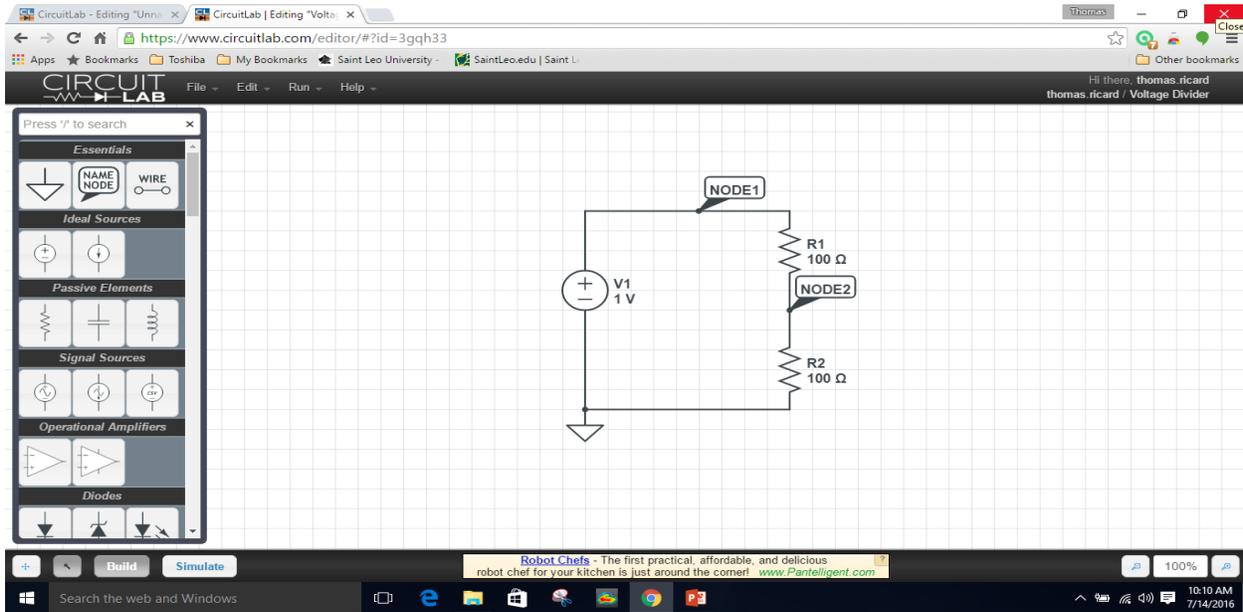

Figure 4 – Voltage Divider Circuit

Simulating Circuits

The software is place in Simulation Mode by selecting the "Simulate" radio button near the bottom left of the display. In Figure 5, the node voltages of the divider circuit are displayed in the left side of the screen after clicking the "Run DC Solver" button.
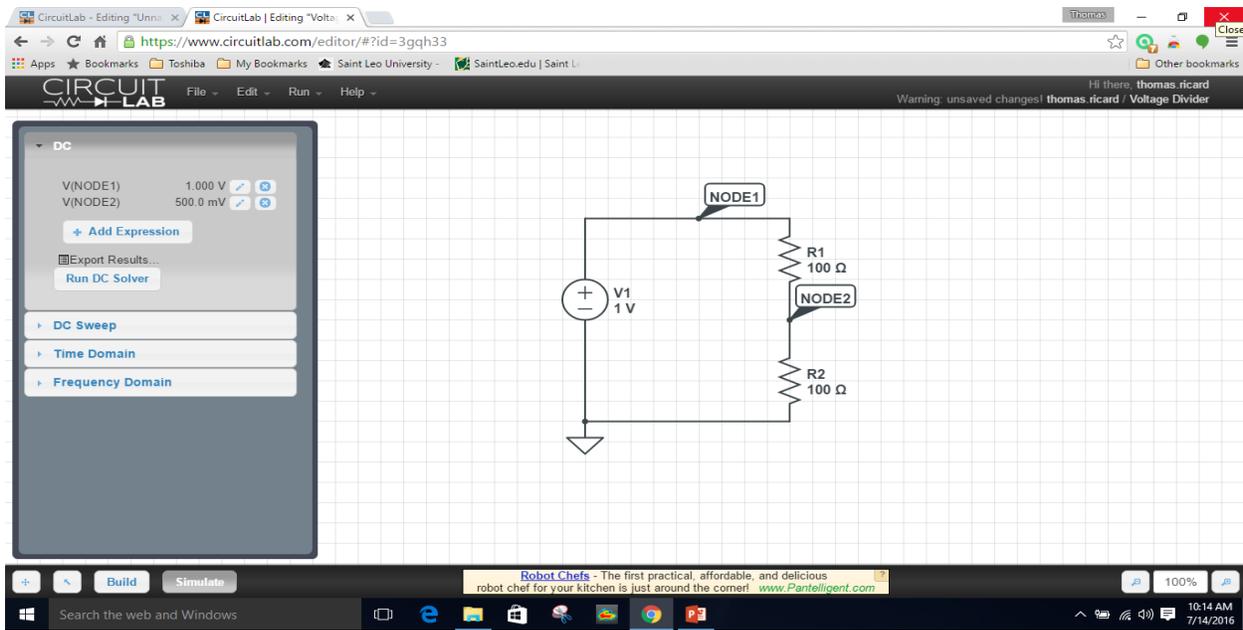

Figure 5 – Node Voltage Solution for Voltage Divider Circuit

CircuitLab also provides for voltmeters and ammeters to be placed into the circuit, rather than by defining nodes. This method is useful in that simulation results are displayed as part of the meter parameters, and therefore incorporated into the schematic. Figure 6 shows a current divider circuit using series ammeters to display current directly onto the schematic.
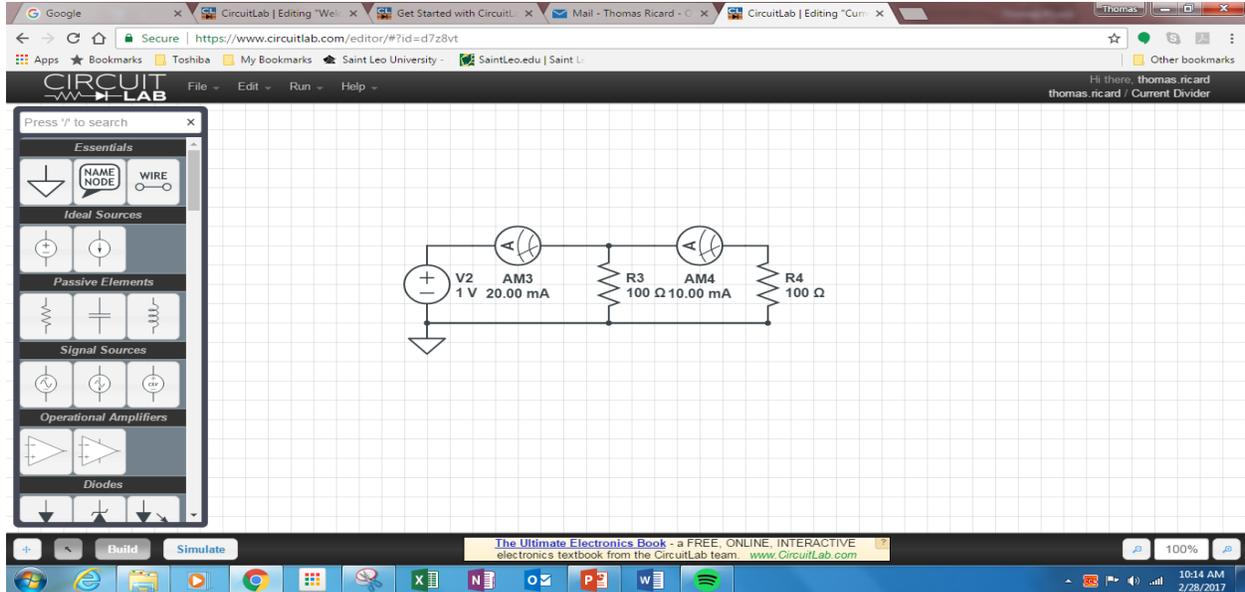

Figure 6 – Using Ammeters as part of a Current Divider Circuit

An AC simulation is used as a final example. The half-wave rectifier circuit of Figure 7 is built using a 1N4148 diode. A different diode model may be selected using the component dialog box discussed earlier. A Time Domain analysis is selected from the Simulation menu. Analysis parameters such as start and stop times and step times (number of data points) are selected by the user.
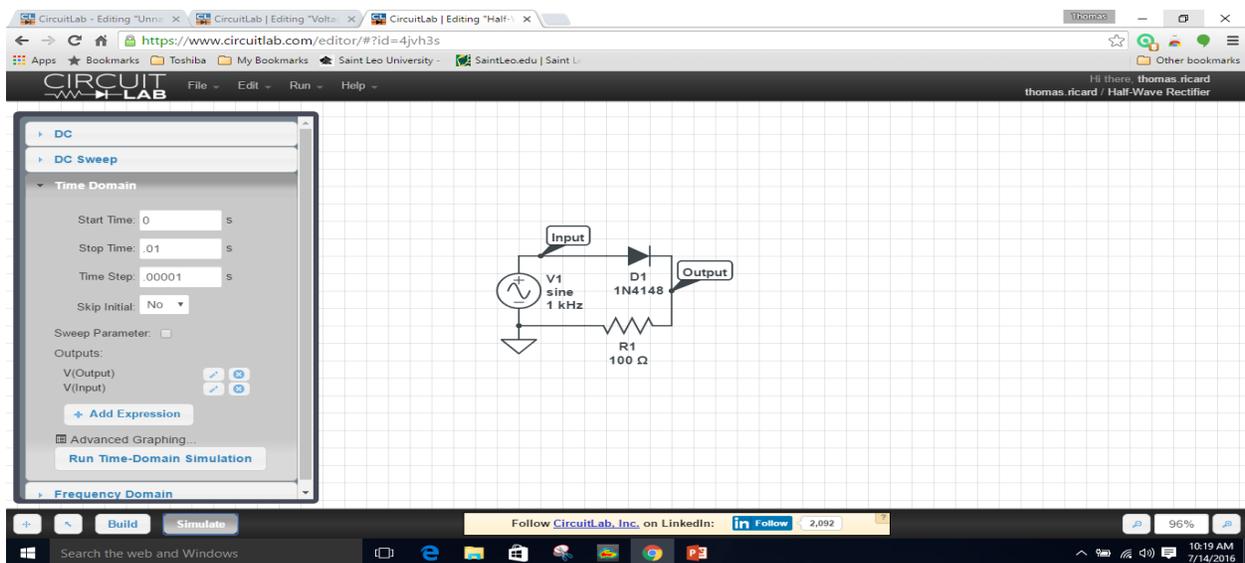

Figure 7 – Half-Wave Rectifier Circuit with Analysis Parameters Entered

The simulation process is initiated by selecting the "Run Time-Domain Simulation" radio button. Time domain results for each defined node are graphed automatically, as shown in Figure 8. Graph formatting (scale, axis definition and labeling) are automatic.
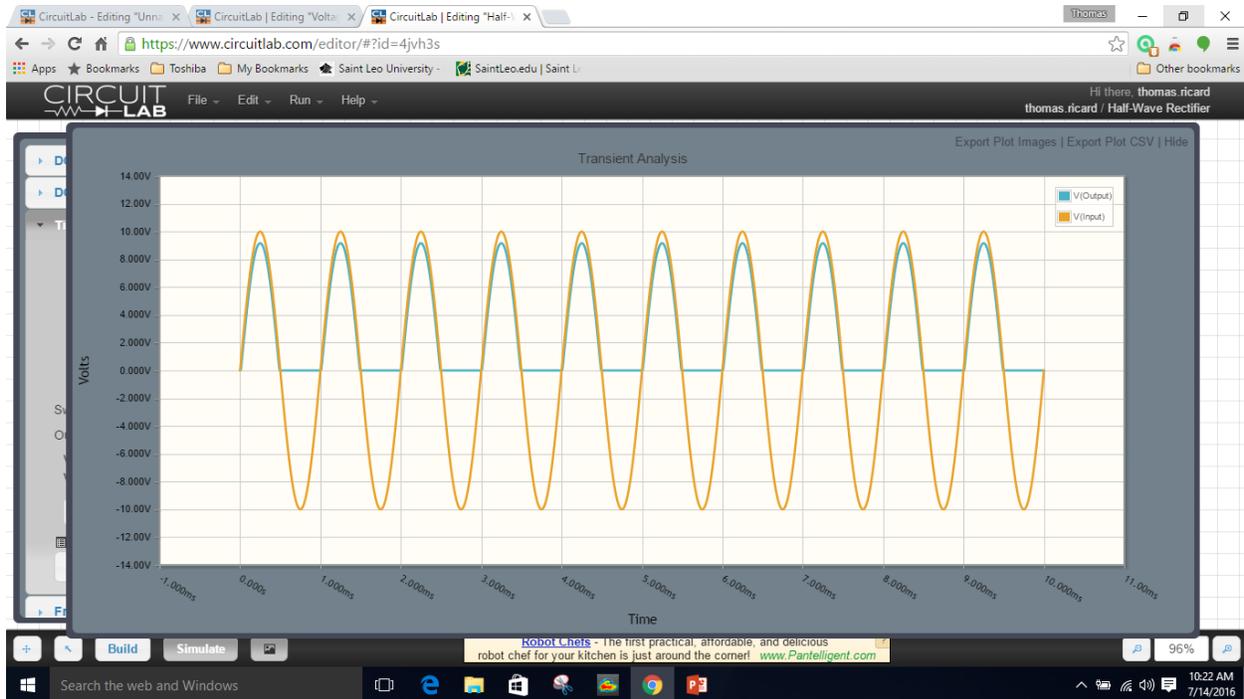

Figure 8 – Time Domain Analysis Results for Half-Wave Rectifier

Browser and Platform Compatibility

The software makes use of the local Javascript engine to perform calculations, therefore an up-to-date version will greatly enhance performance in simulation mode. The author has successfully used CircuitLab on a Windows 10 platform with the following browsers: Google Chrome, Microsoft Edge, Mozilla Firefox and Microsoft Internet Explorer (runs with compatibility warnings). Operation on an iPad is also supported. The author has run CircuitLab using Google Chrome on an iPad, but encountered difficulty accessing stored files when trying to use Apple Safari.

Conclusion

This software was successfully incorporated into the Circuit Analysis course at Saint Leo University, both in a classroom setting and as part of several homework assignments. The students in general became acclimated very quickly to the platform due to its straightforward and intuitive nature. Since software had not been previously used in the course, the introduction of CircuitLab provided students with a much-needed opportunity to double-check their analytical work, in addition to affording them the opportunity to learn and practice basic schematic capture skills. CircuitLab is an effective, low-cost tool that allows smaller educational institutions to integrate simulation tools into their curriculum.

References

1   CircuitLab, https://www.circuitlab.com/ Circuit Lab Inc., accessed Jan 23, 2018
2   ORCAD Capture, http://www.orcad.com/ Cadence Design Systems Inc., accessed Jan 23, 2018
3   Circuits Cloud, http://circuits-cloud.com/ Skrpt Information Technology, accessed Jan 23, 2018
4   Easy EDA, https://easyeda.com/ EasyEDA, accessed Jan 23, 2018
5   Gnucap, http://www.gnu.org/software/gnucap/gnucap.html Free Software Foundation Inc., accessed Jan 23, 2018
6   Qucs, http://qucs.sourceforge.net/ SourceForge, accessed Jan 23, 2018
7   Xyce, https://xyce.sandia.gov/ National Technology and Engineering Solutions of Sandia, LLC, accessed Jan 23, 2018
8   Ngspice, http://ngspice.sourceforge.net/ SourceForge, accessed Jan 23, 2018

Thomas Ricard

Thomas Ricard received his Bachelor of Science degree in Electrical Engineering with Mathematics minor from the University of Hartford and his Master of Science degree in Electrical Engineering from Syracuse University. After spending a number of years in industry as a technician, engineer and engineering manager, Dr. Ricard returned to academia under a National Science Foundation IGERT fellowship, and earned his Doctorate in Electrical Engineering from the University of South Florida. He has been a full-time faculty member at Saint Leo University since the fall semester of 2012 and teaches engineering, science and mathematics classes.