Interactive Virtual Tool for OpAmp Circuits

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Abstract

An interactive application for simulating the behavior of basic ideal operational amplifier (Op Amp) circuits was created. The virtual tool includes options for inverting, non-inverting, summing, and differencing circuits. A user interface allows for circuit resistances to be varied over a limited range. Graphical displays show an input sinusoid and the resulting output sinusoid. The application can be used for in-class demonstrations of circuit behavior or can be downloaded for direct student use. It has low computer requirements and can be run on both Windows and Linux operating systems. The design goals were that selected circuit behavior could be easily displayed and explored.

Keywords

Undergraduate Student Poster, Programming, Software, Virtual Laboratory.

Introduction

Virtual tools for instruction provide flexible options in the learning environment. Lectures can be supplemented quickly and inexpensively with multimedia content. Laboratory preparation can be done with interactive simulations. Virtual instrumentation in electrical engineering courses has long been recognized as valuable and has ongoing development interest [1]. LabVIEW and other platforms give capability for complex virtual experiences [1]-[3]. The device and systems requirements for such tools may be specific and limiting. Virtual tools with less functionality have a place if they can provide selected content with ease of access and use.

The work describes an interactive application for introductory OpAmp instruction. Several basic single-OpAmp circuits are included with interactive functionality for setting gain and with graphical displays of input and output sinusoidal signals. The virtual tool is intended for instructor use as an in-class, multimedia demonstration and for student use in homework assignments or laboratory preparation. A GUI with buttons and slider bars provides users controls. The software was written using Unity [4] and [5]. This software is commonly used for developing computer applications and virtual environments. It is a robust choice for varied operating systems and devices.

Description

The OpAmp application was designed for minimal system requirements and intuitive use. The current version runs on both Windows or Linux operating systems. It provides multimedia content on ideal single-OpAmp circuit performance for non-inverting, inverting, summing, and differencing configurations. The intended educational use is a sophomore-level electronics course. The desired concepts for emphasis were basic resistor networks, dependence on resistor ratios, and circuit gain.

The interface for the inverting circuit option is shown in Figure 1. (Other options are shown in the Appendix.) Users choose the circuit configuration option with a pull-down menu and the resistor values with slider bars. Resistor ratios R_2/R_1 can vary from 1/10 to 10. The graphical display shows a sinusoidal input voltage V_{in} of amplitude ± 1 V (a button selects the amplitude sign) and the resulting output V_{out}. Students have a quantitative and qualitative display of the input-output relationship, e.g. the output is inverted for this option. For the multi-input circuit options, both input voltages are shown.

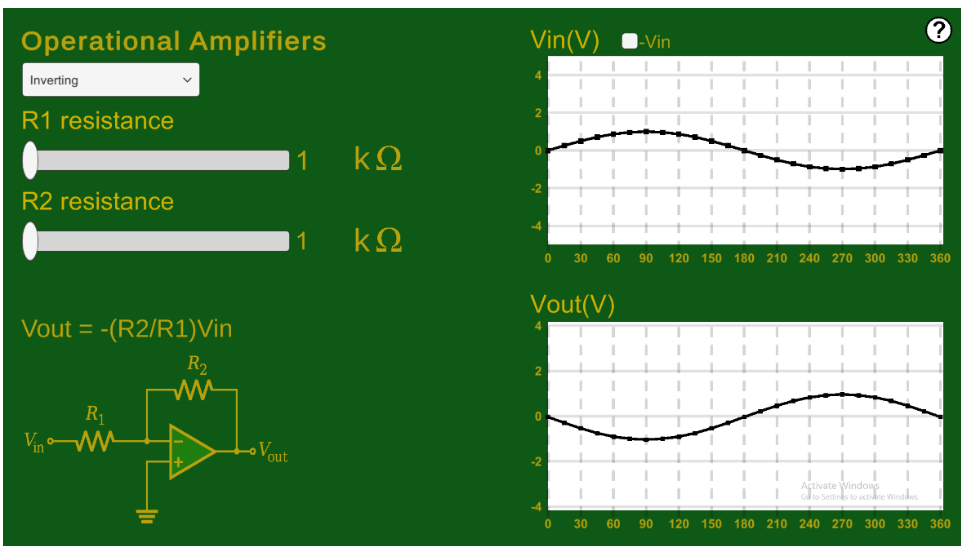

Figure 1. GUI and display for the inverting circuit option.

Summary and Future Work

An OpAmp circuit application was created using Unity with multimedia and interactive features. A preliminary demonstration of the virtual tool was given in a Spring 2023 course with positive responses. After further testing on selected operation systems and devices, the tool will be used for both in-class demonstrations and off-line assignments. A Mac version is planned to accompany the Windows and Linux versions.

References

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Appendix: Tool Options for Basic Ideal OpAmp Circuits

The OpAmp application includes four OpAmp circuits as shown in Figure 2. The circuits are the non-inverting circuit (Figure 2a), the inverting circuit (Figure 2b), the summing circuit (Figure 2c), the differencing circuit (Figure 2d). Note the slider bars for adjusting the resistances. The cases shown are for all resistor ratio at $R_i/R_j = 1$, e.g. the gain for the first two circuits are $V_{out}/V_{in} = +1$ (non-inverting) and $V_{out}/V_{in} = -1$ (inverting), respectively.

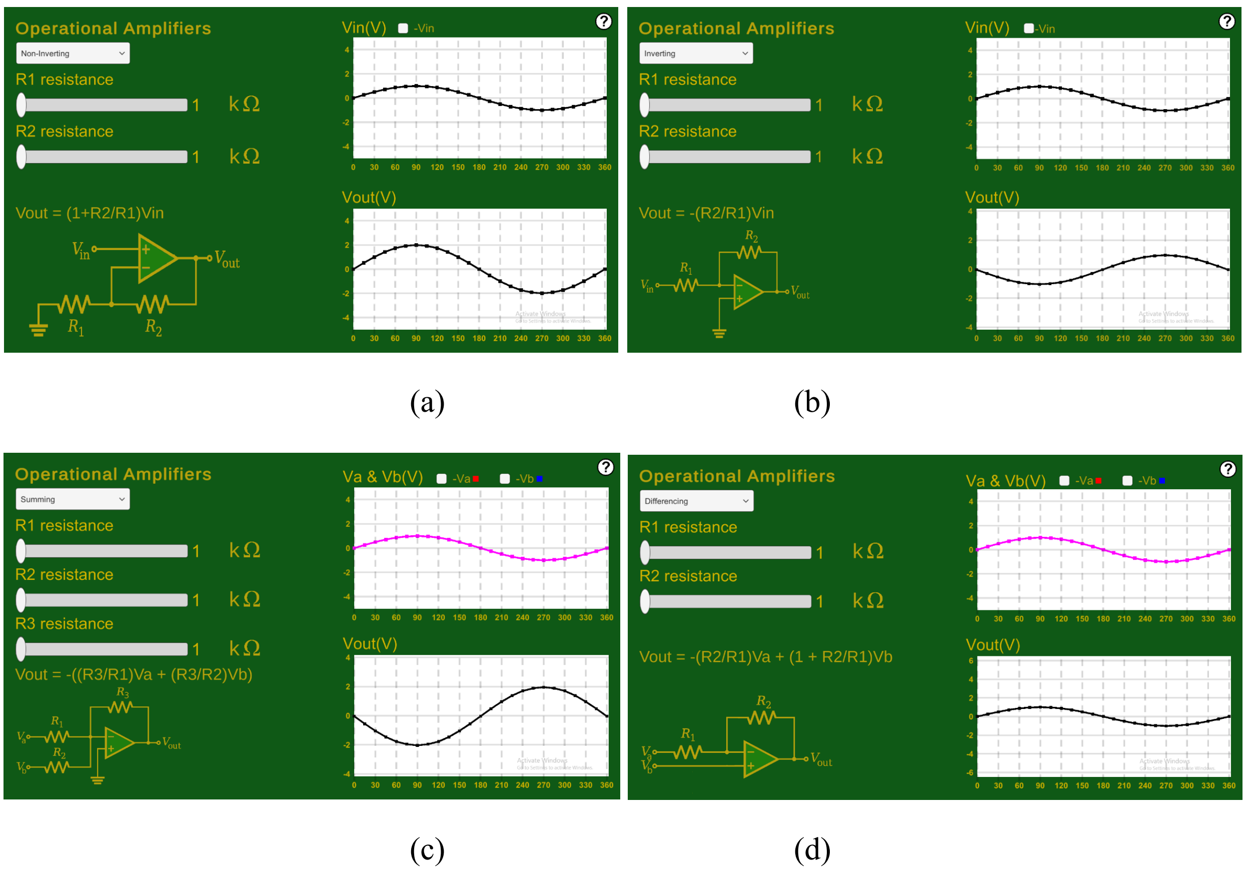

Figure 2. (a) Non-inverting circuit, (b) Inverting circuit,
(c) Summing circuit, and (d) Differencing circuit.