Simulation of Analog and Digital Circuits with the Electronic Workbench

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Abstract:

The improvement of software to simulate electrical circuits has been tremendous in recent years. The new version of Electronic Workbench for Windows (EWB 4.0) is a user friendly simulation program [1]. This paper will focus on providing information on how to use the EWB 4.0 simulation software in the classroom. Students can use this program to design and simulate their Analog, and Digital circuit assignments prior to actual building of the circuit(s) in the laboratory. This paper intends to familiarize the reader with simulation software, in particular, with the Electronic Workbench for Windows version 4.0.

Introduction:

We will first explain the commands, and the method of drawing an electric circuit on the EWB 4.0 screen. Then, we will describe the Component Icon groups, and the Instrument Icons. Five examples will show the convenience and the speed of Electric and Electronic circuit simulations. In the first example we will discuss the use of a function generator, oscilloscope, multimeter, ammeters, and voltmeters to supply and display AC and DC signals. The second example will be a two-stage amplifier with a voltage gain of two. In the third example, the Bode Plotter will be used to display the magnitude, and phase shift of a notch Operational Amplifier (Op-Amp) filter. In the fourth example, the Logic Converter is used to construct a Combinational Logic circuit from a Truth Table. Next, we will use the Word generator, and the Logic Analyzer to display the Timing Diagram of the digital circuit. Finally, in the last example, we will analyze a Sequential and Hybrid Logic circuit. Also, we will show how to simulate four-way switches using single-pole, single-throw (SPST) switches.

Analog Circuit Simulation:

We select the components by clicking on the component and dragging it to the desired position on the screen. We may use the Circuit command to select the appropriate component group prior to the component selection. Once we have placed the components on the circuit, we should connect wires to complete the circuit. Click on a node of a component, and drag the mouse over to a node on another component. The two components will connect. Double click on the wire, and select the color for that wire. Note that we use different wire colors in order to have multicolor signals on the Oscilloscope. After completing the circuit, we are ready to use the instruments available in the software to analyze the circuit. Figure 1 displays the Electronic Workbench's analog instruments.

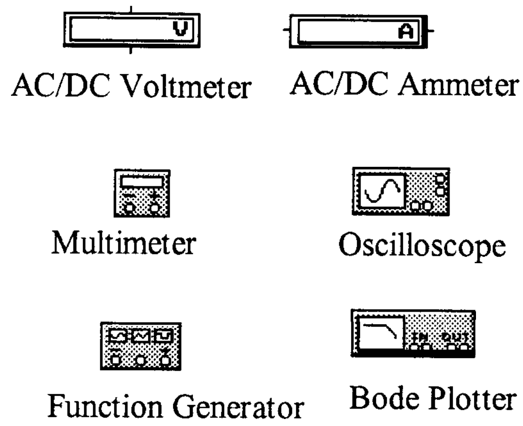

Figure 1. The Analog Instruments

Several AC/DC Voltmeters, and Ammeters can be used in a circuit, but there is only one Multi-meter available to be used. "Double Click" on the instrument to expand its Icon, in order to see the function buttons on the instrument. Figures 2 through 5 display the Multimeter, the Function Generator, the Oscilloscope, and the Bode Plotter, respectively. Note that the Instrument's functions emulate very closely the actual instruments.

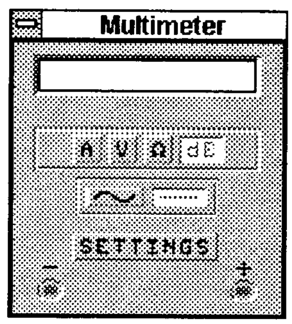

Figure 2. The Multimeter

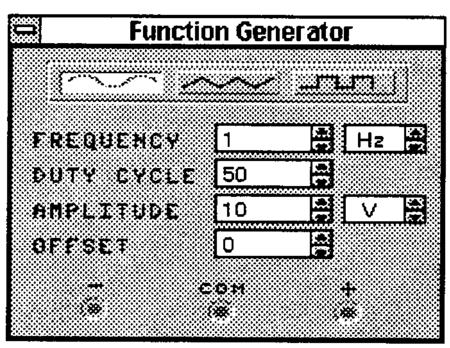

Figure 3. The Function Generator

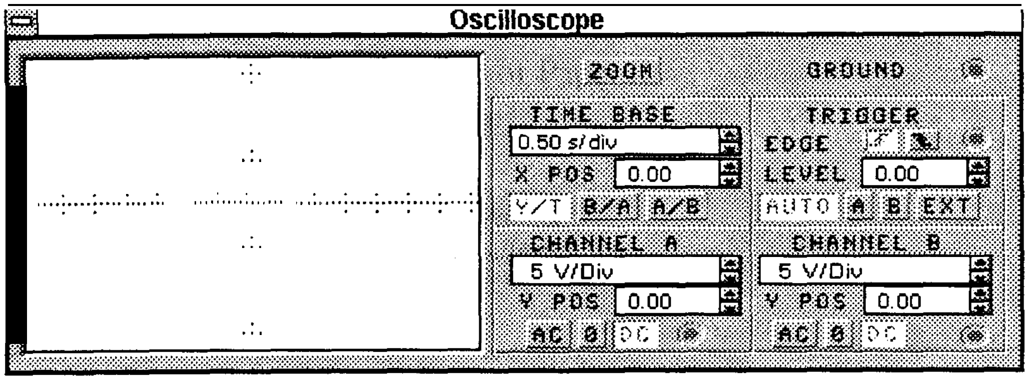

Figure 4. The Oscilloscope

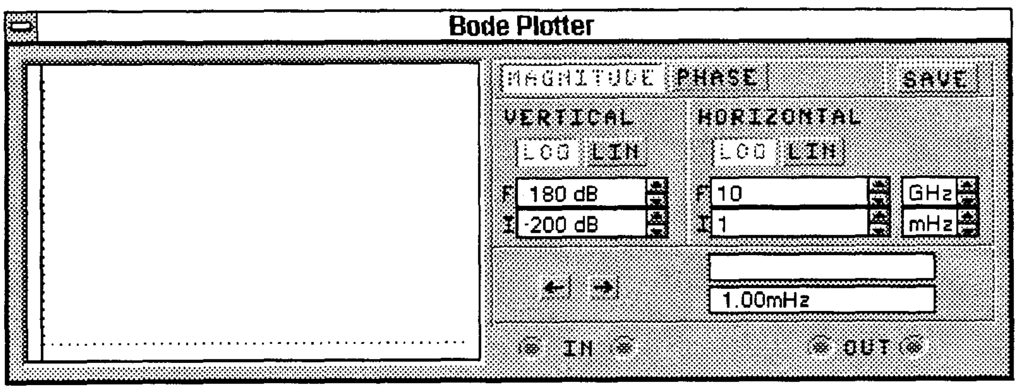

Figure 5. The Bode Plotter

Figure 6 shows a DC circuit, where two ammeters, and one voltmeter are used to measure currents, and voltage. Figure 7 displays an AC circuit with a Function Generator, and Oscilloscope.

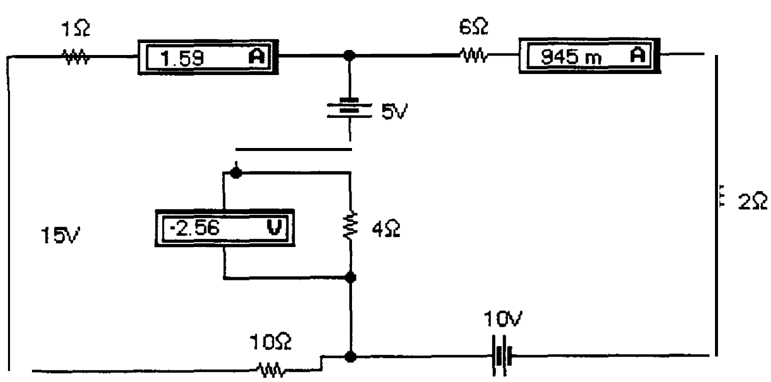

Figure 6. DC Circuit

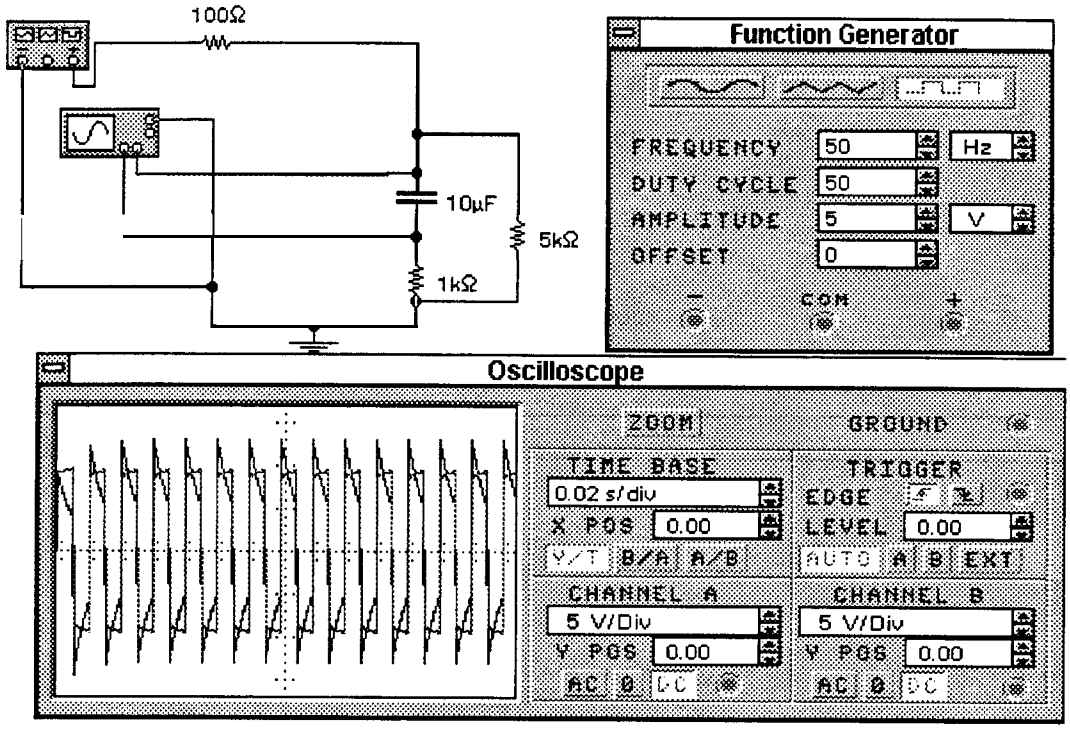

Figure 7. AC Circuit

In Figure 8a, Voltmeters, and an Oscilloscope are used to measure the DC biased voltages, and the AC input and output signals. This circuit is a two-stage amplifier with a voltage gain of two. Figure 8b, shows the input and output signals of the amplifier circuit.

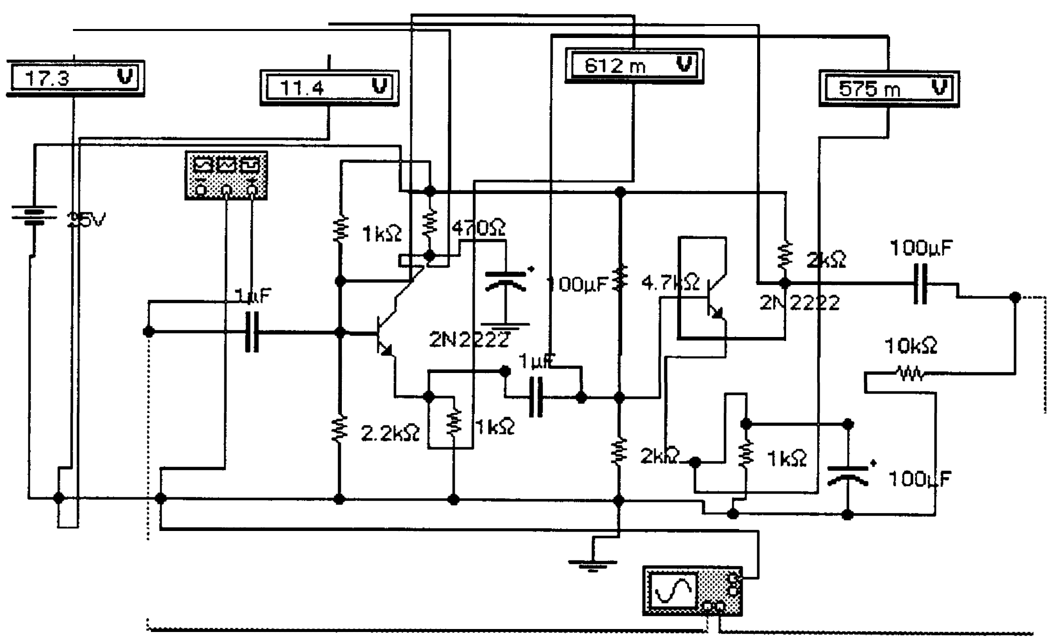

Figure 8a. Two-stage Amplifier circuit with a Voltage Gain of two

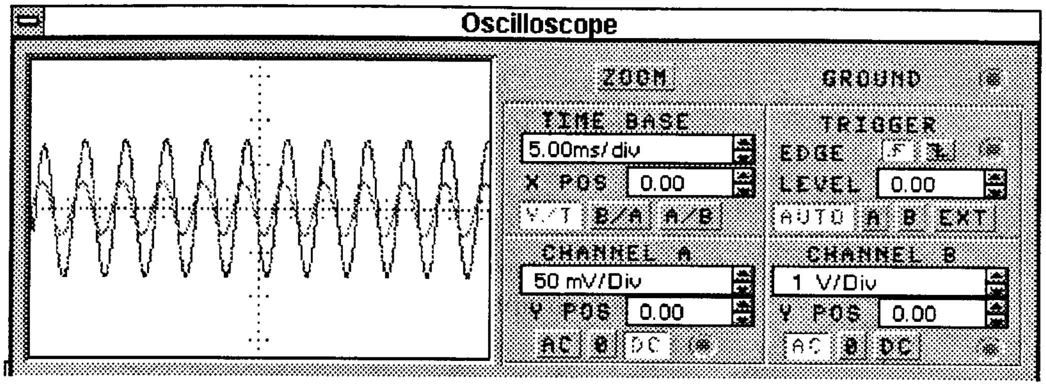

Figure 8b. Input and Output signals of the circuit in figure 8a

Figure 9 shows a notch OP-Amp filter. The Bode Plotter displays the amplitude characteristic of this filter. This circuit will filter out 60 Hz AC hum from any low voltage audio source. The cutoff frequency is determined by the equation.

$$\frac{1}{2Pi*R*C}$$

Where, RI =R2=R3=R4=R5=R,

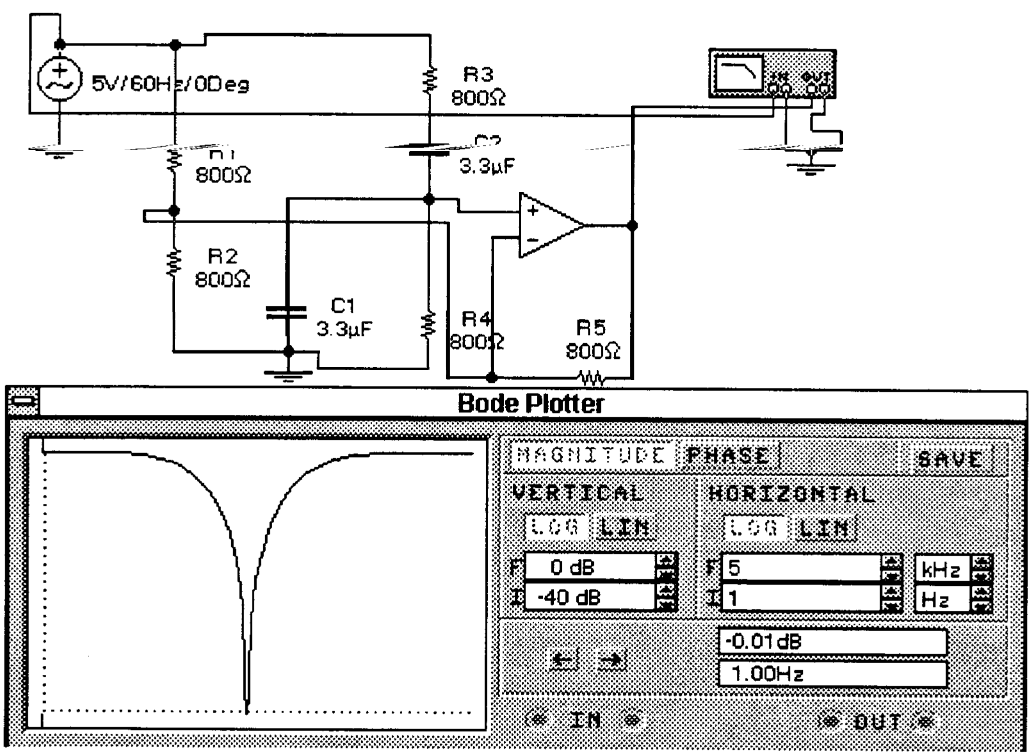

Figure 9. A Notch Op-Amp Filter

Digital Circuit Simulation:

The logic converter instrument displayed in figure 10 can be used to build the Combinational Logic Circuit from a Truth Table, or find the Truth Table for a Logic Circuit. Also, the Boolean Equation can be obtained from either the Truth Table, or the Logic Gate.

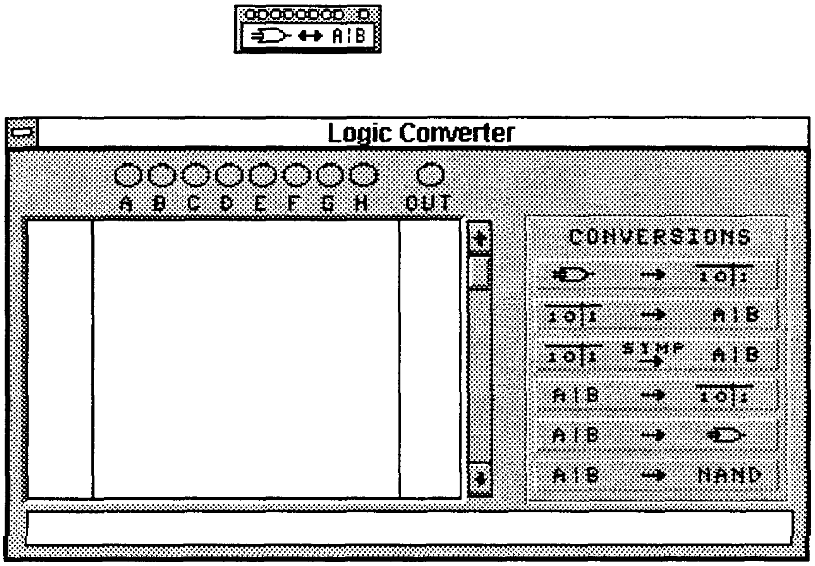

Figure 10. The Logic Converter

Figure 11 shows the Word Generator. Note that sixteen step patterns for eight bit words can be saved, and used repeatedly to feed different logic Circuits.

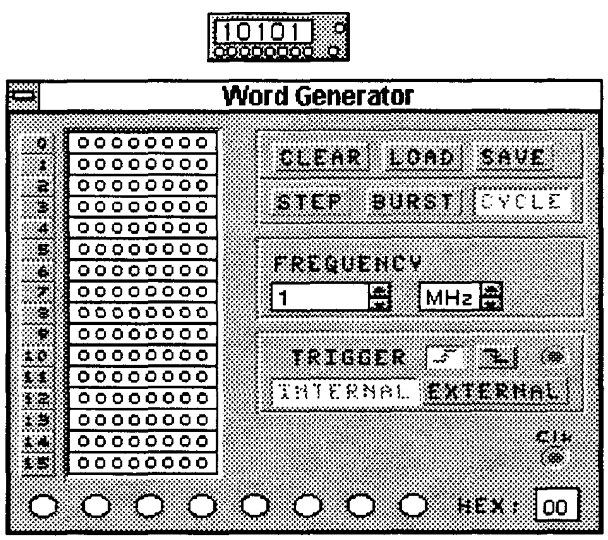

Figure 11. Word Generator

Figure 12 shows an eight-channel logic analyzer. The wires connecting the input or output signals should be assigned different colors in order to be able to distinguish between them when the signals are on the Logic Analyzer screen.

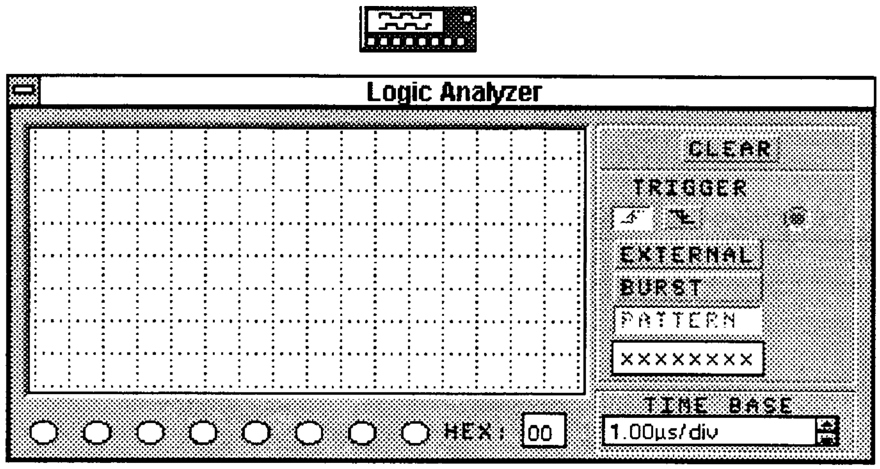

Figure 12. The Logic Analyzer

In figure 13a, the Word Generator, and Logic Analyzer are used to display the input and output signals of a Combinational / Sequential Logic Gate. Figure 13b displays the input and output signals for the circuit in figure 13a.

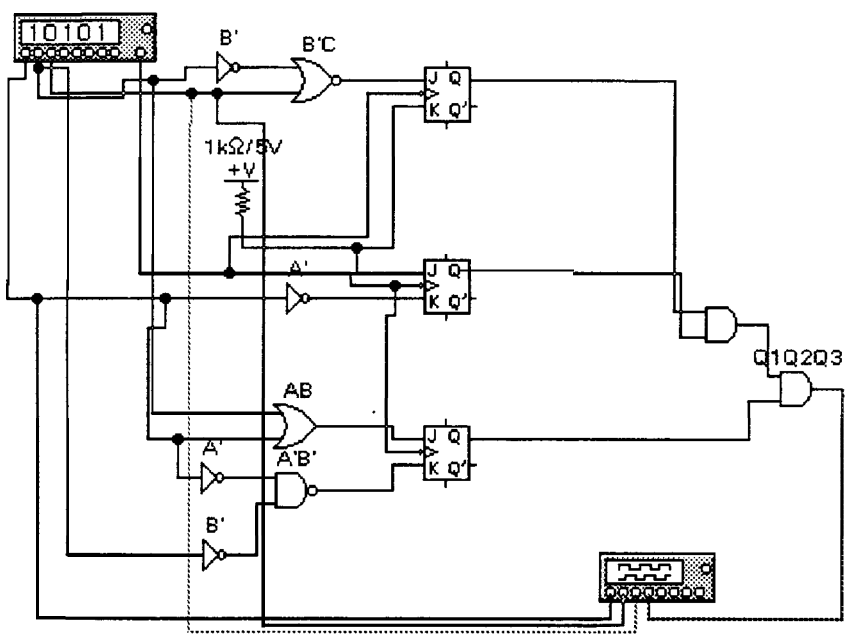

Figure 13a. A Combinational/ Sequential Logic Circuit

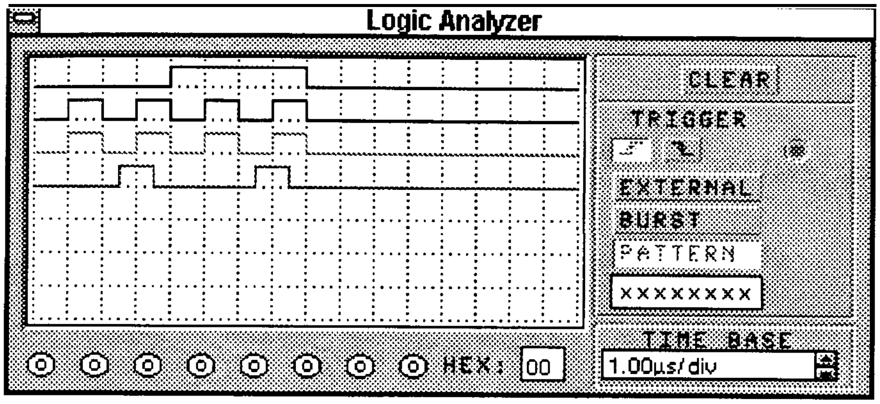

Figure 13b. Input and Output signals for the circuit in figure 13a

Figure 14 displays a circuit in which both analog and digital components are used. The buzzer will sound whenever the count reaches “F” (hex), that is “15” (decimal).

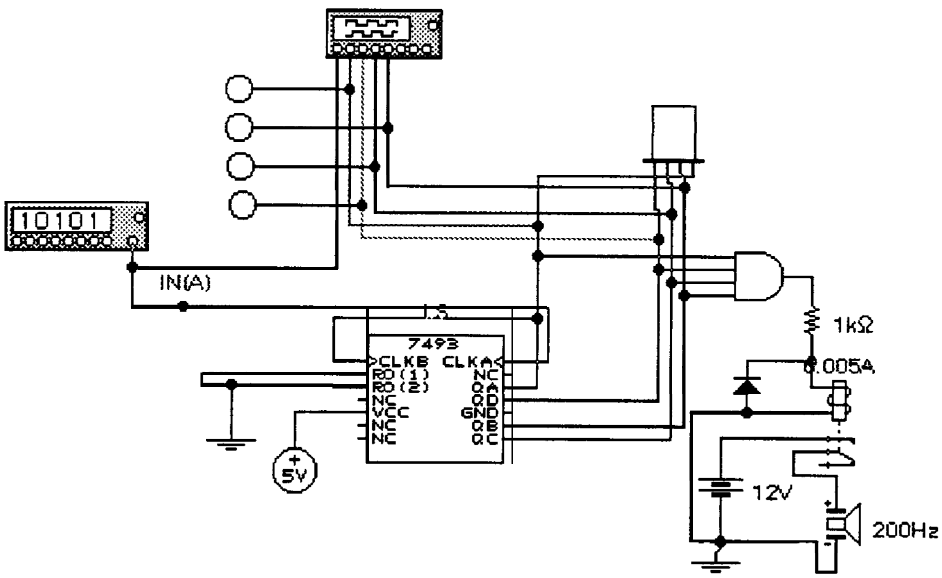

Figure 14. Binary Counter Circuit

Simulating Four-Way Switch:

Figure 15 shows a lighting circuit for a commercial building. The 4-Way switch is often used in halls, and large conference rooms. The switch can make, or break using one of the three switches located in different positions. In the figure single-pole, single-throw (SPST) switches are used to simulate and illustrate the electrical connection of the four-way switch. Pressing either the S-key, T-key, or the space-bar on the computer keyboard will cause the 75 watt light bulb to turn on, or off.

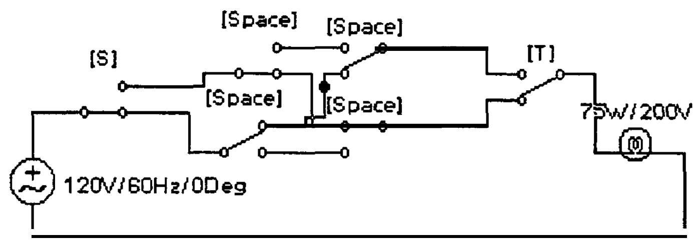

Figure 15. Simulating 4-way Switch

Conclusion:

This paper intended to introduce the simulation power, and flexibility of Electronic Workbench for Windows. During the presentation at the 1996 ASEE Annual Conference, the author will familiarize the participants with the method of using this package to simulate different types of electronic circuits. The benefits of using simulation software before the actual connection of the circuit, and signal measurement is substantial. Students will have a good understanding of how the circuit will operate, and what the signals should look like. For further information on Electronic Workbench the reader needs to contact the Interactive Image Technologies Ltd., at 1-800-203-8007.

Reference:

1. Electronic Workbench for Windows 4.0, Interactive Image Technologies Ltd., 700 King Street W, Suite 815, Toronto, Ontario, Canada M5V2Y6.

Massoud Rabiee received his Ph.D. in Electrical Engineering, from University of Kentucky, in 1987. He is presently an associate professor at Eastern Kentucky University. Dr. Rabiee is a registered professional Engineer in the State of Kentucky, and a member of IEEE, ASEE, and NAIT.