

Design & Implementation Interface for Electrical or Electronics Lab Simulator

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Abstract—In the current world, it's almost impossible to imagine that someone can live without computers. Computers have become an electronic device of almost every day use for individuals of every age. They are essential in almost all the business dealings that are made nowadays. Electrical circuits are the building blocks of all electronic devices whether they are simple devices such as digital watches, timer circuits or sophisticated devices such as mobile phones, Laptops, etc. While designing new circuits, errors may occur that can have adverse effects sometimes leading to monetary loss. Therefore, a need for virtual electrical laboratory arises. Electrical circuits can be tested in a virtual environment before the actual physical implementation to prevent any kind of loss. This “Virtual Lab Simulator Using Java ” project aims at providing a user-friendly GUI to easily and quickly assemble circuits and get the required output. “Virtual Lab Simulator” will be a java-based project, so it will be compatible with all operating systems supporting java. The GUI part will be implemented using java swing components (Jpanels and Jframes).

Keywords-GUI; MVC; GNU; UMI;KCI;KVL.

I. INTRODUCTION

Building new electronic device means designing new electrical circuits. Once a circuit is designed, it has to be tested and verified for the required results before putting it into actual physical implementation. While designing a new circuit, errors may occur. Circuits may malfunction that can sometimes lead to serious consequences such as component loss leading to financial losses. Also it is difficult to rectify the circuit by changing the wires between terminals of different electrical components especially while dealing with very complex circuits. Taking into account the above mentioned facts, the need for some virtual environment simulating the basic electrical laboratory arises. This paper aims at providing a user friendly Graphical User Interface (GUI) tool that can be used to implement the circuits in the virtual environment and check for the behavior of circuits. The tool provides the basic components such as resistors, capacitors, inductors, power source, voltmeter, ammeter etc. These components can be used to implement a simple circuit and check if the circuit is behaving in a way it should have

behaved in a real world. Also with the software, it can easily modify the circuit, changing the connections/components with only a few clicks of mouse. The circuits can be rectified rather easily using this tool opposite to changing the circuit in reality on a breadboard. So basically in this paper we are providing a user friendly Graphical User Interface (GUI) to the user so that they can implement the real life electronic circuits virtually on this simulator and can rectify if any error occurs. In this way damages due to error in electronic circuits in real life can be reduced to fewer in number and helps in preventing any kind of hazards.

II. EXISTING SYSTEM

Initially all the required components resistor, inductor, capacitor, voltmeter, ammeter etc. are brought in the lab near a power source. Then the circuit is established manually according to the requirement and the current, voltage etc. are checked using voltmeter and ammeter and then using Ohm's law and Kirchhoff's voltage law and current law are calculated at various junctions and the circuit is modified till the

required output is found and then according to the values of different components original circuit is made.

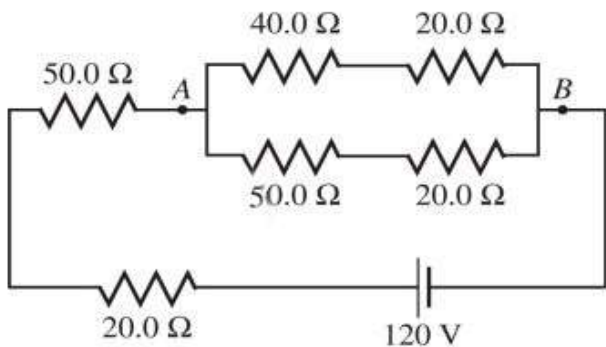


Figure 1. An Electric Circuit

A) Methods to Solve this Circuit.

- Ohm's law:-
 Voltage (v) = Current (I) * Resistance (R)
- Kirchoff's Current Law:-
 Total current entering a junction or node is exactly equal to the total current leaving the node.
 i.e. $I_{(exiting)} + I_{(entering)} = 0$.
- Kirchoff's Voltage Law :-
 The algebraic sum of all voltages within the loop must be equal to zero.

B) Solving the Circuit:-

- By using Ohm's law the amount of current passing through each resistance is found. In 20 ohm resistance the amount of current passing is equal to $I = V/R$ i.e. $I = 120/20 = 6$ ampere.
- Similarly, the amount of current entering in 50 ohm resistance will also be 6 ampere and the current exiting current from 50 ohm resistance will be equal to –
 $R' = R1 + R2$ (as 20 ohm and 50 ohm resistance are in series).
 $R' = 20 + 50 = 70$ ohm.
 $I = 120/70 = 1.71$ ampere.
- In this way further calculation is done.

III. PROPOSED SYSTEM

Building new electronic device means designing new electrical circuits. Once a circuit is designed on the paper, it has to be tested and verified for the required results before putting it into actual physical implementation. While designing a new circuit, errors may occur. Circuits may malfunction that can sometimes lead to serious consequences such as component loss leading to financial losses. Also it is difficult to rectify the circuit changing the wires between

terminals of different electrical components especially when we are dealing with very complex circuits.

Taking into account the above mentioned facts, the need for some virtual environment simulating the basic electrical laboratory arises. This system provides a user friendly Graphical User Interface (GUI) tool that can be used to implement the circuits in the virtual environment and check for the behavior of circuits. The tool provides the basic components such as resistors, capacitors, inductors, power source, voltmeter, ammeter, etc. These components can be used to implement a simple circuit and check if the circuit is behaving in a way it should have behaved in a real world. Also with the software, it can be easily modify the circuit, changing the connections/components with only few clicks of mouse. The circuits can be rectified rather easily using this tool opposite to changing the circuit in reality on breadboard.

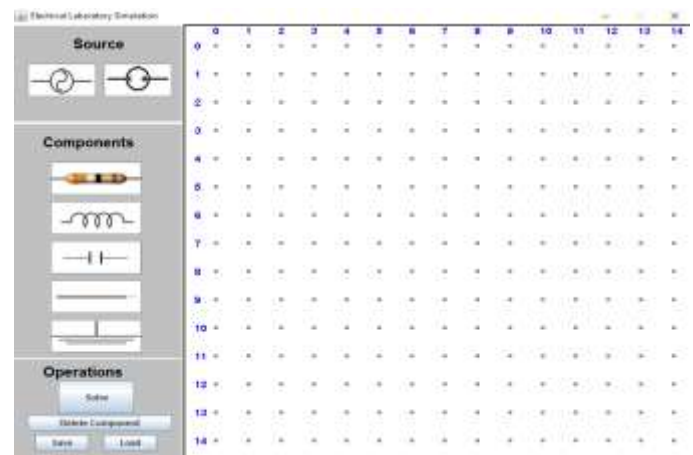


Figure 2. Interface of lab simulator

Left panel contains power source, different electrical components and the operations to be done on the circuit and the right panel is workspace consisting of 15 * 15 grid of nodes across which components are added using drag and drop from the left panel.

IV. IMPLEMENTATION OF SYSTEM

This System will be implemented using MVC architecture:-

Model-View-Controller (MVC) is a software architecture pattern which is used to separate application's concerns. MVC pattern separates the modelling of the domain, the presentation, and the actions based on user input into three separate classes.

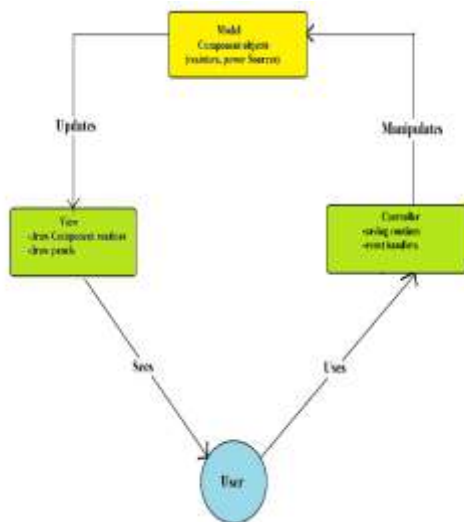


Figure 3. MVC Architecture of the System

- **Model:** -The model of MVC architecture will be taking care of the data and behavior of the application domain and it will also reply to all the requests for information about its state (generally from the view), and will react to the instructions to change the state (generally from the controller).
- **View:** The view will manage the display of information for the GUI.
- **Controller:** The controller will elucidate the keyword and mouse inputs from the user, informing the model and/or the view to rectify as appropriate.

A) Design:-

As shown in figure 2, left panel consists of power sources, different electronics' components registers, inductor, capacitor, wire, earthing and it also consists of different operations like save, delete, solve, load. Right panel is the workspace consisting of 15 * 15 grid of nodes across which different electronics components available in left panel are added via drag and drop and the circuit is made.

B) Implementation of GUI:-

In this system GUI is implemented using Java Swing. The panel on the left side containing all the components is a JPanel. On the right side, we have a grid of small buttons which become green when clicked. These buttons can be thought of as the holes in a breadboard used for making circuits.

User has to select the two buttons across which he wants to put the electrical component. Once the buttons are selected, electrical component is chosen from the list of components provided in the left panel simply by clicking on the required

component. After clicking on the component, a frame pops up asking for the details of the component selected. If user selects a resistor, it will ask for the resistor value or the color code scheme followed in resistors. After getting all the required values, the component is inserted across the two buttons selected in the workspace on the right. Thus, the whole circuit can be assembled step by step by first using the two terminal points across which the component is to be inserted and then selecting the component with required details.

C) Circuit Solving:-

- First of all circuit is simplified. The simplifier removes wires i.e. it joins two end points of a wire to create a single junction.
- It removes one of the junctions from all the electrical components and assigns second junction of wire to all the electrical components. The circuit solver creates an array of junctions (nodes) involved in the circuit.
- It will assign zero potential to grounded terminal. If not present, then it assigns zero potential to negative terminal of DC power source.
- It applies Kirchhoff's Current laws and voltage laws to create a matrix of coefficients of junctions with unknown potential.
- It will solve the equations by finding inverse of matrix. After finding potential at each node one can easily find current flowing through any electrical component.
- Formula used :-

1. Ohm's law: $V=IR$

2. Kirchhoff's Current Law:

$$\sum_{n=1}^N I_n = 0$$

3. Kirchhoff's Voltage Law:

$$\sum_{n=1}^N V_n = 0$$

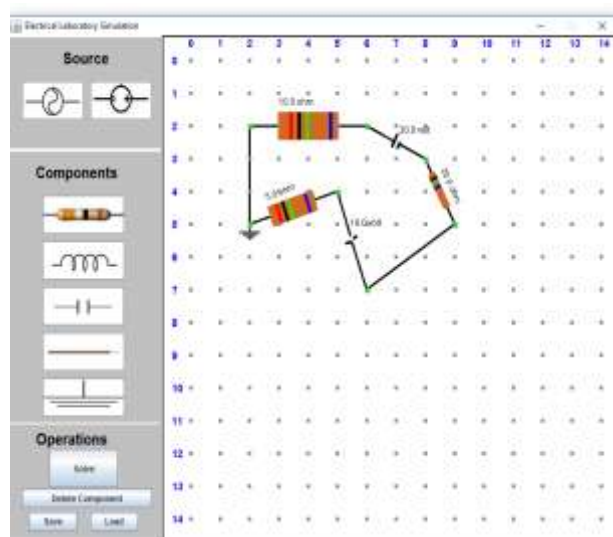


Figure 4. Circuit drawn on workspace using components from the left panel via drag and drop.

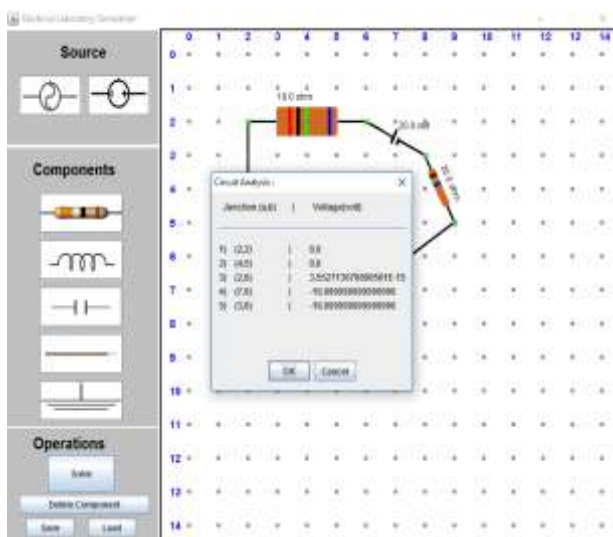


Figure 5. Circuit Analysis and voltage is mentioned at each junction of the circuit .

V. FUTURE SCOPE

The world of electrical circuits is very vast and expanding. New circuits are being designed each day and the older ones are improved. So, the simulation of large variety of circuits is quite a difficult task. There are many types of electronic components involved in making these circuits. So new components can be added to our existing system to solve complicated problems. For e.g. to include more components such as ICs, diodes, transistors etc. To include more analytical features such as graphs of required output. Setting operating temperature for the analysis. To include further type of analysis, i.e. DC Analysis, Transient Analysis, AC Analysis. It can provide Learning Management System around the Virtual Labs where the students can get

opportunity of the various tools for learning and implementing various electronics /electrical circuits for their academics.

VI. CONCLUSION

This papers offers the user a simple and easy way to design and implement the circuit virtually and study its behavior. Its interface is very user-friendly. One can design a circuit in just few clicks of the mouse. The world of electrical circuits is very vast and expanding. New circuits are being designed each day and the older ones are improved. So, the simulation of large variety of circuits is quite a difficult task. There are many types of electronic components involved in making these circuits. E.g. resistors, capacitors, inductors, diodes, transistors, integrated circuits (ICs), transducers, switches, power sources and many more. Further, there are many topologies of circuits (components can connect in various fashions). So, modeling each and every type of circuit is a challenging task.

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