National University of Computer and Emerging Sciences

Digital Logic Design

Lab 01

Fast School of Computing

FAST-NU, Lahore, Pakistan

Objectives

- Simulate, analyze, and integrate digital circuits with LogicWorks
- Exploring BASIC Gates in Digital Systems

- Truth table of logic circuit ,its implementation, Boolean identities and complement of function

Contents

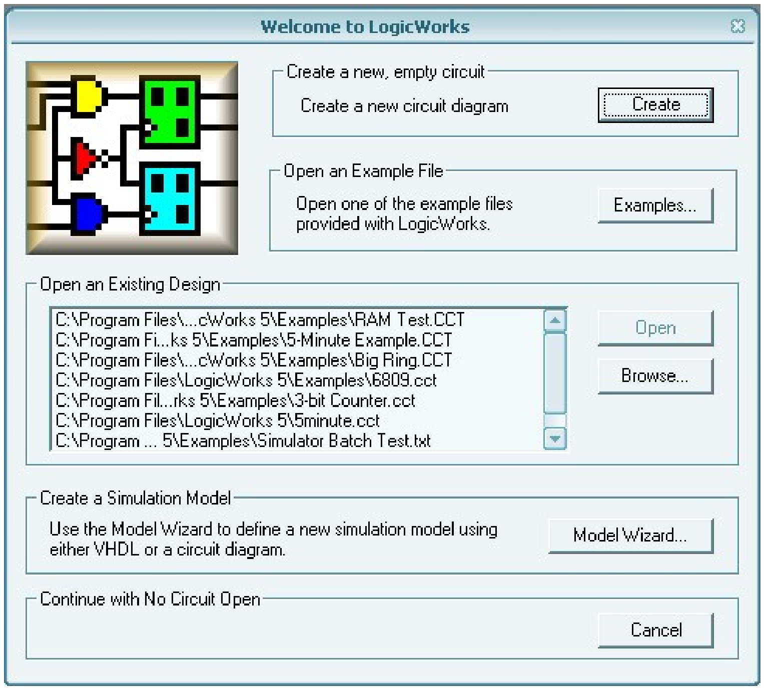
Tutorial on LogicWorks

"LogicWorks is an interactive circuit design tool intended for teaching and learning digital logic." LogicWorks 5 is the newest version of LogicWorks. It is a program that we can use for designing and simulating circuits. This lab material will introduce you the basic features of LogicWorks and familiarize you with the program by stepping you through the construction of a simple circuit. [1]

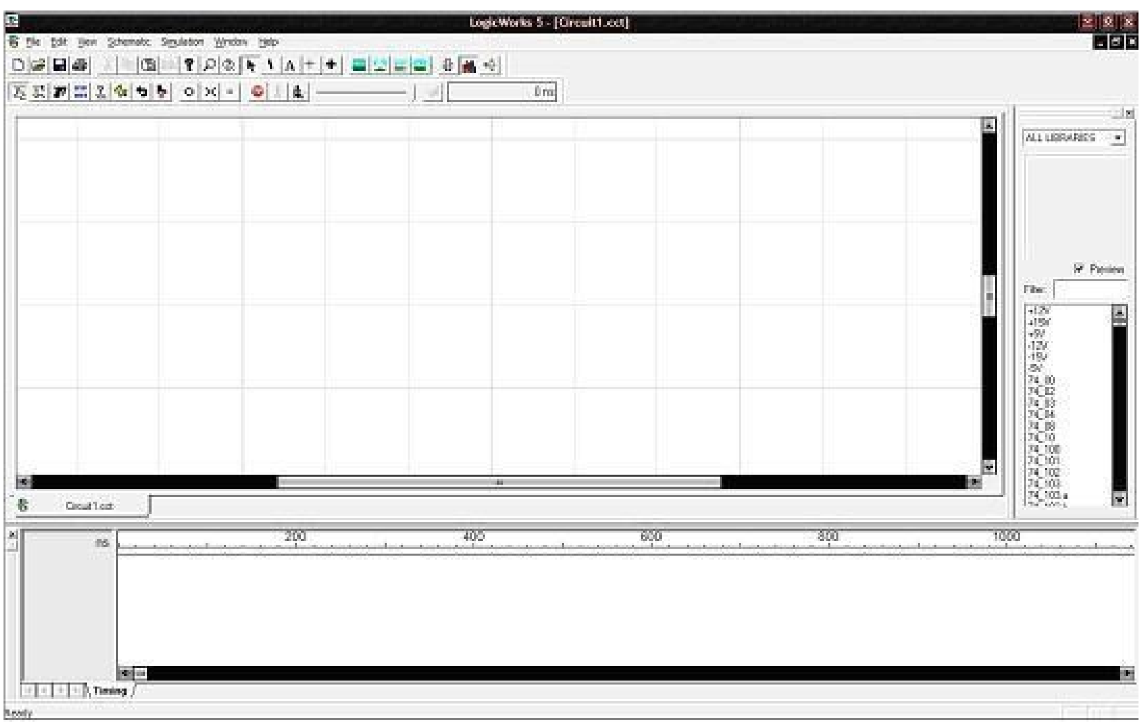
Start up LogicWorks

You start LogicWorks by clicking on the icon 

on the desktop or selecting it from the Microsoft Windows Start menu. Once the tool is open, you will see the "Welcome to the LogicWorks" screen.



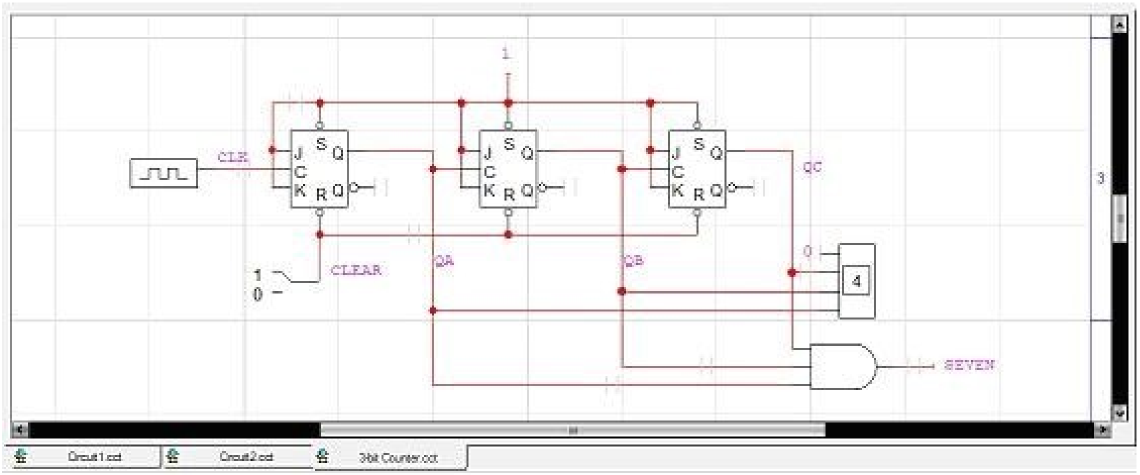
Select "Create a new circuit diagram" by clicking on the "Create" button. Then the following screen is displayed.



There are three primary window components in LogicWorks. They are Circuit Window, Timing Window, and the Parts Palette. Now let's look at each of them.

Circuit Window

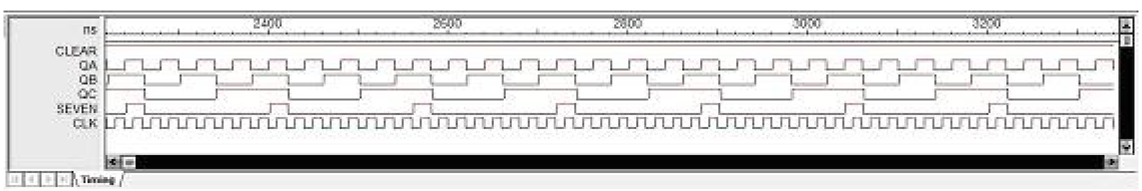
The circuit window is where you build your circuits. For example, you can select different parts from the Parts Palette and place the device in the circuit Window to build your circuits. The following is a screen capture of the circuit window with a sample circuit already drawn.



You can select any part of the circuit by left clicking on it, once selected, a right click can bring up a pop menu that displays the options for manipulating the selected component.

Timing Window

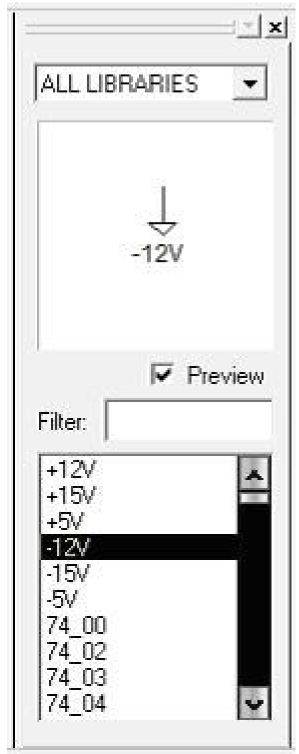
When a circuit is simulated, the Timing diagram window can be displayed to show signal values versus time. Only one Timing window can be displayed at any given time, and it gives waveforms generated by the current design. Closing the Timing window does not close the circuit design file. The following picture shows the corresponding timing window of the above example circuit.



Like the Circuit window, the intervals of the timing diagram can be selected by using click and drag the mouse over the desired interval. Once a section of the diagram is selected, right click brings up a pop menu with options that can be used to manipulate the Timing diagram.

Parts Palette

Parts Palette is another very important part of LogicWorks interface. By default, it is located to the right of the Circuit Window. The location can be changed by holding down the left mouse button on the double stripped title bar near the top and dragging the window to the desired location. Usually, I would recommand that you keep it in the default location.



When you click on a device, it shows in the preview area. This is illustrated by the above picture. Parts Palette contains a group of parts libraries. You can choose a library and select a device by double clicking on the device name, then place it in the Circuit Window for building circuits.

Build a Circuit

In this section, you will build and test a circuit that implements the following Boolean equation:

$$Z = AB + BC + AC'$$ **This**

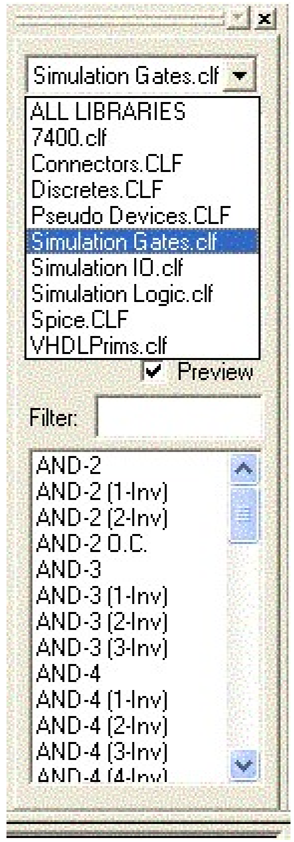
requires the following components:

1. Three AND gates with two inputs (AND-2)
2. Two OR gates with two inputs (OR-2)
3. A single NOT gate commonly called an inverter
4. Some wire to connect the gates
5. Three switches to provide a way to modify the input values for testing
6. A binary probe to show the results of the circuit

The first three components can be found in the "Simulation Gates.clf" library:

- Click on the pull-down menu on the Parts Window
- Click on the "Simulation Gates.clf" library.

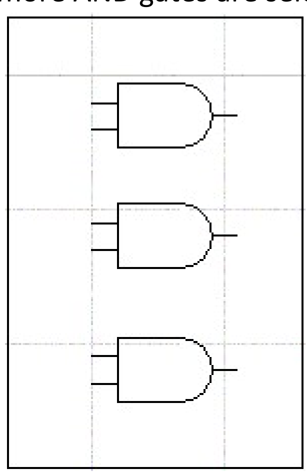
"Simulation Gates.clf" should now be displayed in the pull-down menu window of the Parts Window as shown in Fig. The next portion of the Parts Window displays a list of the logic gates contained in this library. The scroll bar can be used to view them all.



Put the desired devices on the schematic (The Circuit Design Window):

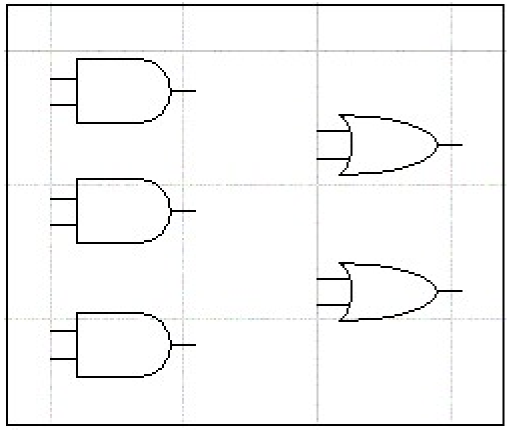
1. **AND Gates:**
   - Find the AND-2 gate in the Parts Window and double click on it.
   - Move the mouse pointer to the Circuit Design Window and place three of these gates where you want them by clicking once for each gate. See Fig.

   Note: Spreading the gates apart a little makes it easier to connect parts to them later.
   - Hit Esc/Space so that no more AND gates are selected.

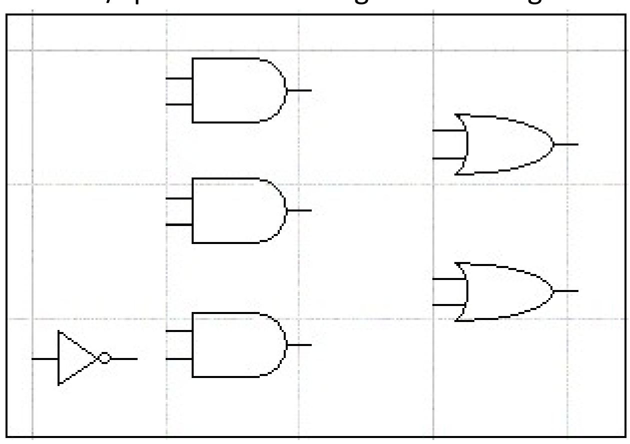


2. **OR Gates:**
   - Find the OR-2 gate in the Parts Window and double click on it.

- Move the mouse pointer to the Circuit Design Window and place two of these gates to the right of the AND gates. See Fig.
- Hit Esc/Space again so no more OR gates are selected.



3. **NOT Gates (Inverters):**
   - Find the NOT gate in the Parts Window and double click on it.
   - Move the mouse pointer to the Circuit Design Window and place one NOT gate to the left of the bottom AND gate. See Fig.
   - Remember to hit Esc/Space so the NOT gate is no longer selected.



Moving and deleting existing gates:

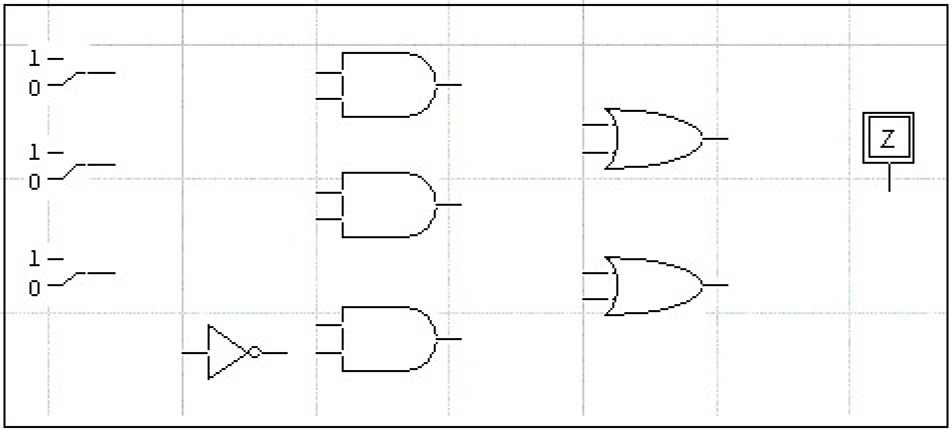
By single clicking on an item on the schematic (The Circuit Design Window) the device will be selected and highlighted. While the device is selected, the Delete key will remove the item from the circuit window. To move a device, point at it and hold down the left mouse button, then move the mouse to the desired location. Release the mouse button.

4. **Adding switches:**

- Click on the pull-down menu in the Parts Window.
- Click on the "Simulation IO.clf" library.
- Note: This library contains primitive Input and Output (I/O) devices such as "Binary Switch", "Binary Probe", etc.

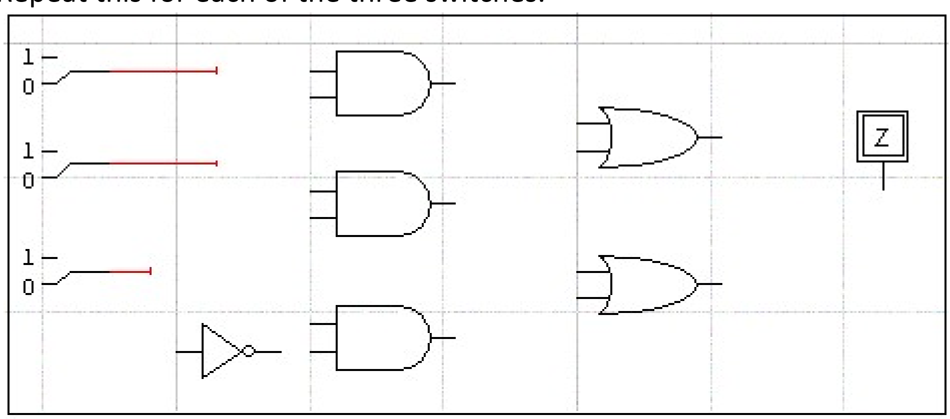
- Double click on the binary switch entry and place three of them on the circuit window on the left of your design.
- Doulble click on the Binary Probe entry and place it on the circuit window on the right of your design.

Your design should now resemble the circuit window in Fig.



Connecting the Devices:

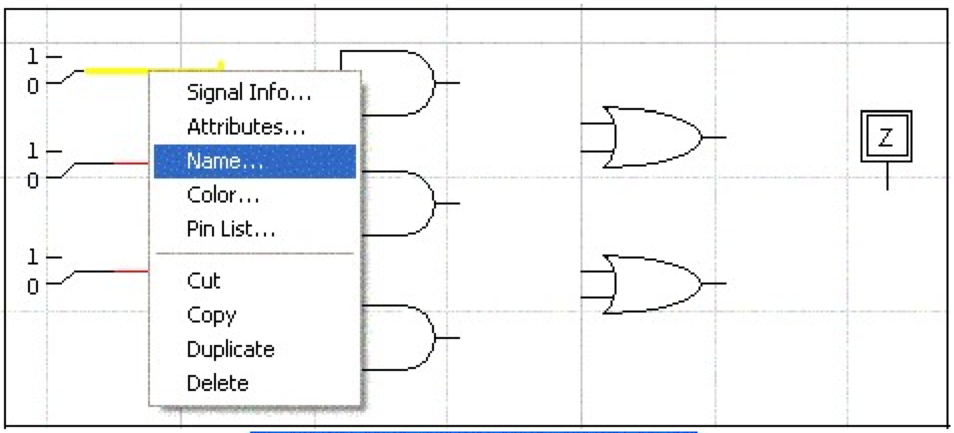
5. **Adding wires:**
   - Place the cursor on the right edge of the switch and hold down the left mouse button.
   - Drag the mouse a half-inch or so to the right and release the button. A red wire should now be attached to the switch, ending in the middle of nowhere. See Fig.
   - Repeat this for each of the three switches.

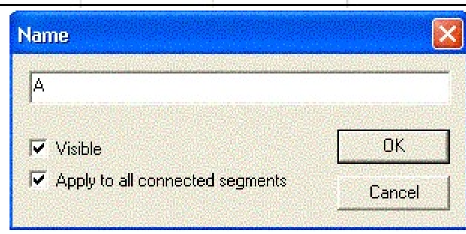


Recall that we are trying to implement Z = AB + BC + AC'. To clarify your design and show its relation to the equation above, we will label the wires A, B, C, and Z.

6. **Labeling wires:**

- Right-click on the wire you want to name.
- Select Name from the box that appears, as in Fig.
- Type the name of the wire in the text box. Be sure to check Visible.

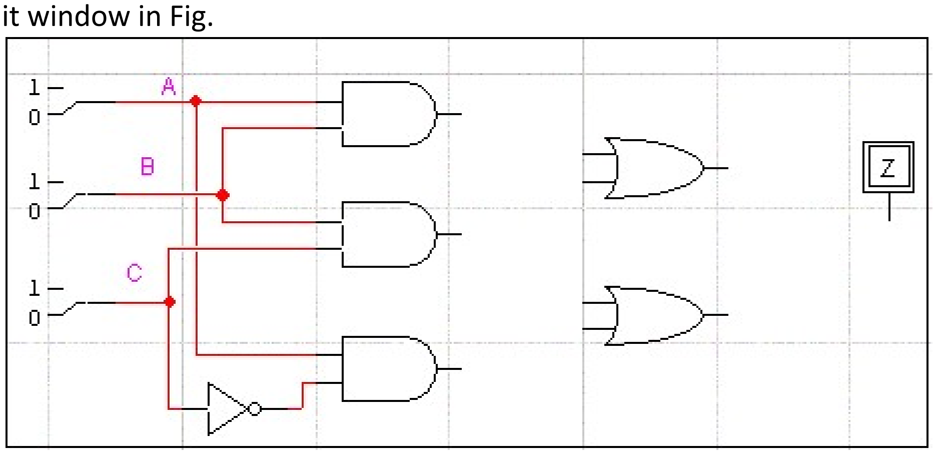




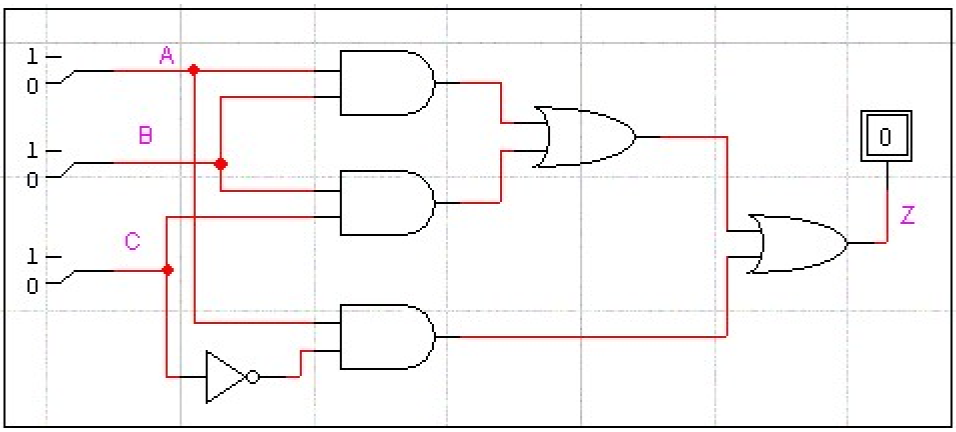
When you named these wires you should have noticed that in The Timing Window the names appeared. This will later show you the values of these three variables.

Connect the devices together with wires:

- Place the pointer on the end of the wire extending from switch A and hold down the left button, then drag the mouse to an input of the first AND gate. You have now connected the switch for input A to the first input of the AND gate.
- Connect the wire from switch B to the other input of the first AND gate in a similar manner.
- Click on the first input of the second AND gate.
- Drag a wire to any point of the wire extending from switch B. A dot will appear on the intersection if the wires were successfully connected.
- Connect the C switch wire to the input of the inverter.
- Connect the output of this inverter to one of the inputs of the last AND gate and connect the other AND gate input to switch A. Your design should now resemble the circuit window in Fig.



- Connect the outputs of two of the AND gates to the inputs of one of the OR gates.
- Finally we connect the output of the remaining AND gate and the output of the first OR gate to the input of the last OR gate.
- The Binary Probe should now be connected to the output of the final OR gate and the wire should be labeled Z. See Fig. 10. Notice that the output Z showed up in the Timing Window.



Simulation Controls

Here is the Simulator Toolbar:

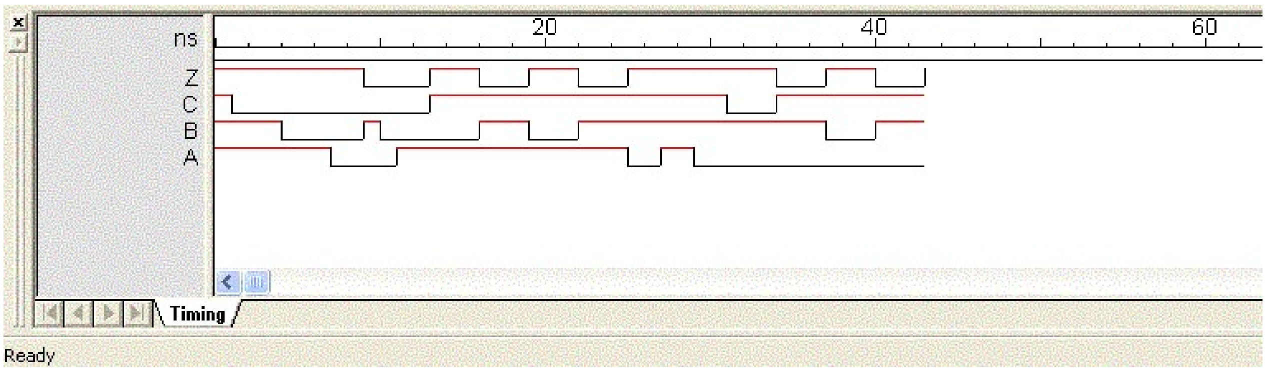
Position your mouse pointer on each botton, you will find the function of each of them. You may try it on your own. For example,

- Clicking on the <> or >< button can adjust the range of the time values to suit the display data.
- Clicking on the Reset button can make the simulation restart at time 0.
- Clicking on the Run button can start the simulation.

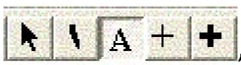
You may have noticed that in the Timing Window that there are small lines drawn like underscores for inputs A, B, and C. These are low because the switches are all set to the zero value.

Testing your Circuit:

- Click on the handle of switch A to point to the value 1.
- Change the values of A, B, and C and observe the results in the Timing Window.
- Click on the button <> in the Simulator toolbar. This will stretch the time out, making the waveforms easier to see.



Inserting Text in the Circuit Window:

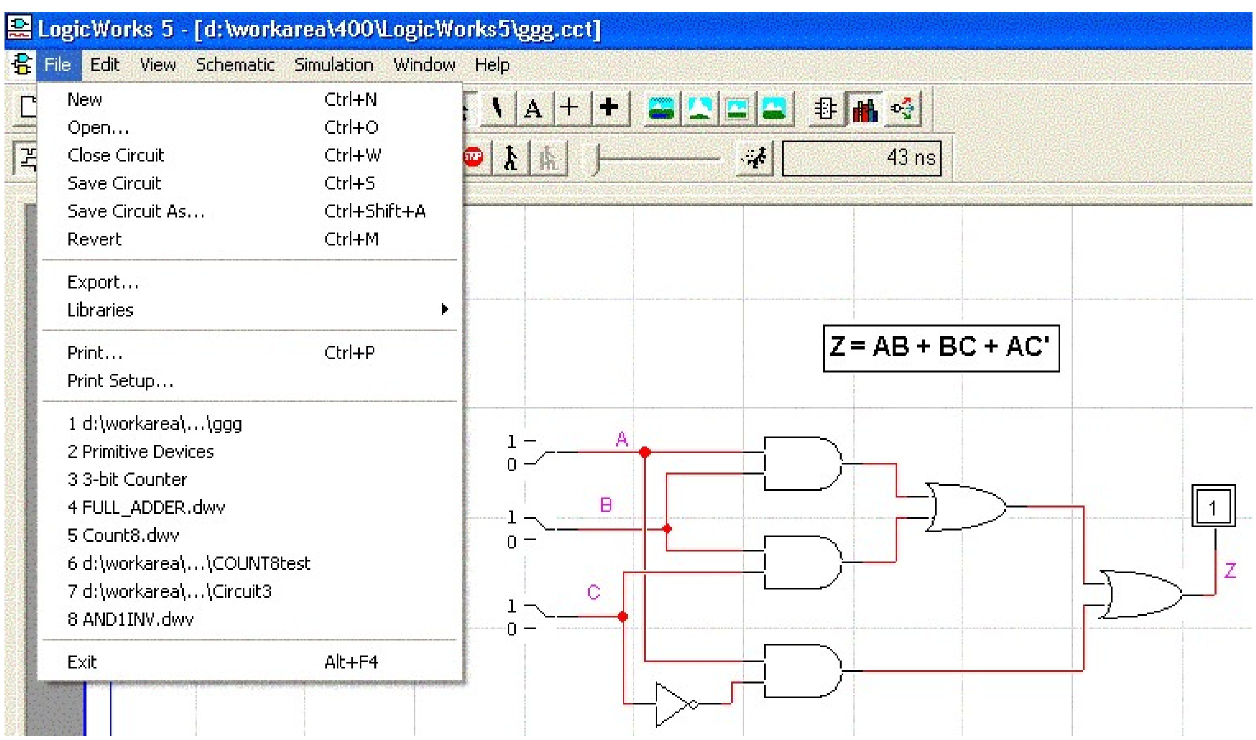
To insert the text in the circuits window, click on the button A in the design toolbar , then follow the following steps.

- Position your pencil (cursor) at the desired location.
- Type in the text
- Change cursor to the pointer by clicking on the pointer in the toolbar or press the space bar or escape key.
- Click on the text entered, then right click.
- Select "Text Style" and then select the preferred options and then, press ok.

Look at the next picture, you can see the Equation of the circuit in the circuit design window.

Saving and printing your work:

To save or print your work, click the File menu and then select the proper option. The following picture illustrates the idea.

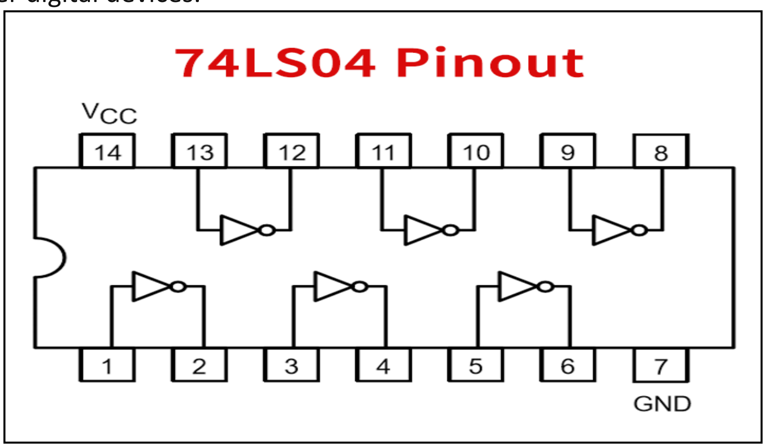


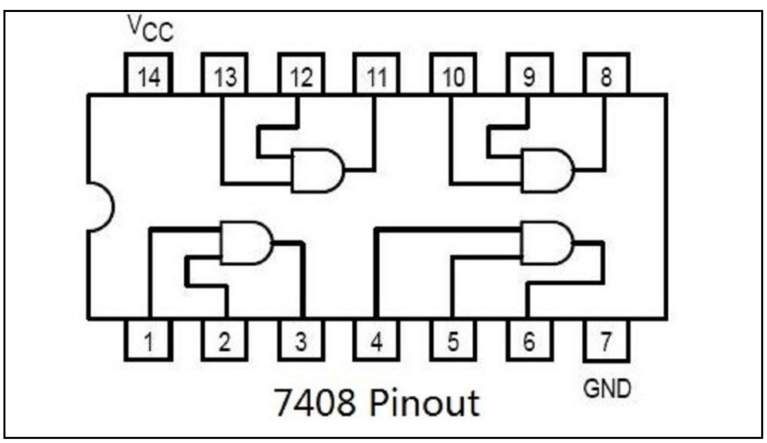
NOT, AND, OR Gate ICs

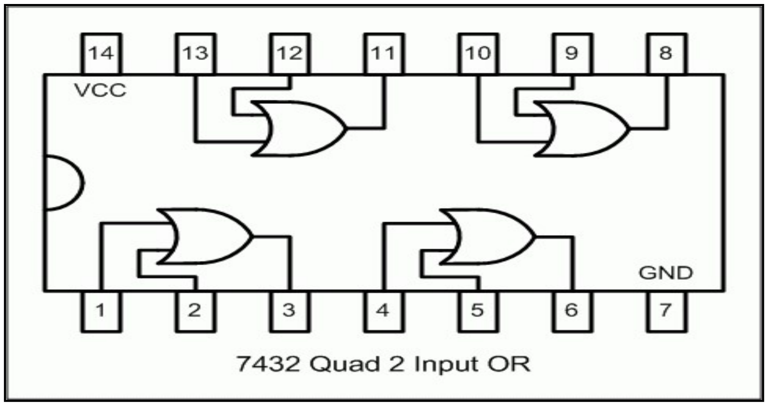
Here is a brief explanation of the working of 7404, 7408, and 7432 ICs:

- **7404**: The 7404 IC is a **NOT gate** IC that contains six independent NOT gates. A NOT gate is a logic gate that produces an output that is the opposite of its input. In other words, if the input is high, the output is low, and vice versa.
- **7408**: The 7408 IC is an **AND gate** IC that contains four independent AND gates. An AND gate is a logic gate that produces an output that is high only when all of its inputs are high. Otherwise, the output is low.
- **7432**: The 7432 IC is an **OR gate** IC that contains four independent OR gates. An OR gate is a logic gate that produces an output that is high when any of its inputs are high. Otherwise, the output is low.

These ICs are used in digital circuits to perform logical operations. They are widely used in computers, calculators, and other digital devices.







TASK 1#Testing NOT Gate IC , OR and AND gate IC

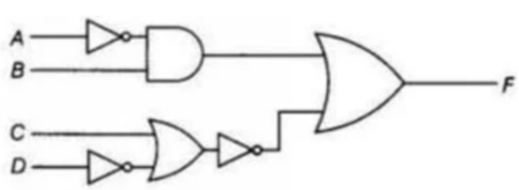
TASK 2# For the Boolean expressions given below simplify these expressions using Boolean identities, draw the truth tables and the circuit diagrams of the simplified Boolean Equations. Implement the simplified Boolean equations on the trainer.

a. (AB'+AC+B')

b. (P'Q'+PQ) R+(PQ') R

TASK#3

For the circuit given in figure below, obtain its Boolean equation. Simplify the Boolean equation. Implement it on Logic Trainer.



Task 4:

Find complement of following equation.

1. F3 = (X'Y')+(Y'Z')+(X'Z)