Lab Manual

CS302 – Digital Logic Design

Prepared by
Waqar Ahmad, Lecturer
Waqas Ahmad, Instructor

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Lab Experiment # 01

Familiarization; Playing with EWB 5.12

Introduction to Electronics Workbench

Electronics Workbench is an electronics and digital logic lab inside a computer, modeled after a real electronics workbench. It is a design tool that provides you with components & instruments to create "virtual" board-level designs:

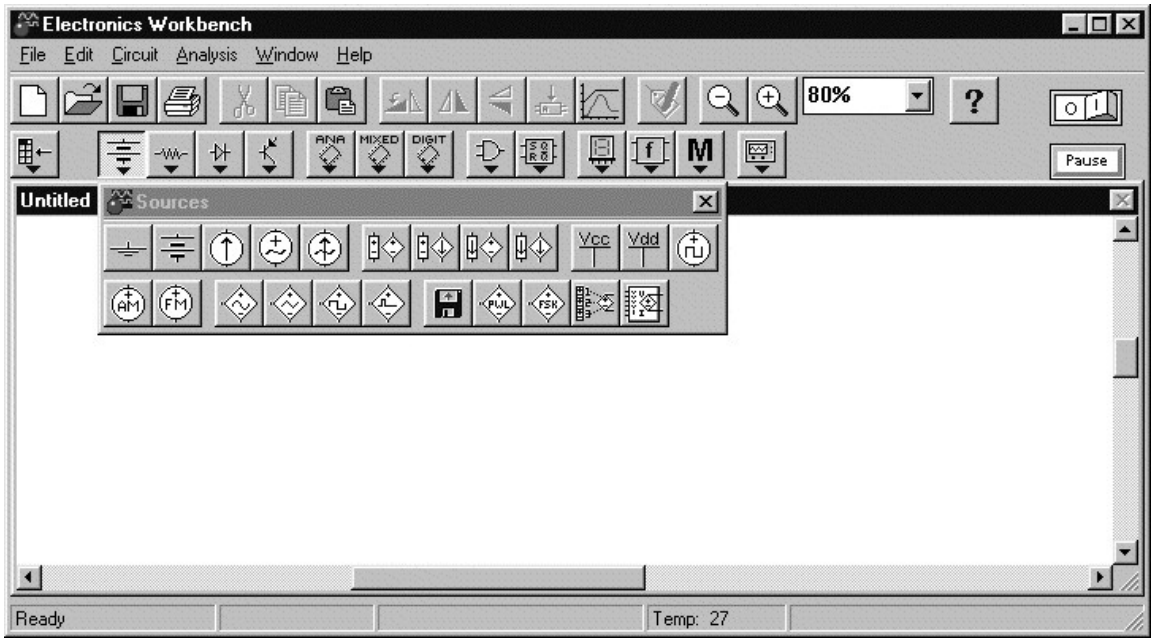
– No actual breadboards, components, or instruments needed.

– Click-and-drag schematic editing.

– It offers mixed analog & digital simulation and graphical waveform analysis.

– Circuit behavior simulated realistically.

– Results displayed on multimeter, oscilloscope, bode plotter, logic analyzer, etc.



The main GUI interface of EWB

Using Electronics Workbench for Design

You may use EWB to:

1- Explore ideas and test preliminary circuits.

2- Refine circuits to full layout (If circuit requires parts of a previous design)

3- Export files in format used by PCB (Printed Circuit Board) layout packages as move from design to production.

General EWB Functions

Selecting

– To move a component or instrument need to select it selected item highlights: components red, wires thicken

– *Clicking to Select*

To select single item, click on it.

To select additional items, press CTRL+ click.

– *Selecting All*

Choose Edit/Select All.

– *Dragging to Select*

Place pointer above & to side of group of items. Press & hold mouse button & drag downward diagonally. Release mouse button when rectangle encloses everything desired.

– *Deselecting*

To deselect single item, press CTRL+click.

To deselect all selected items, click on empty spot in window.

Setting Labels, Wiring

Setting Labels, Values, Models & Reference IDs,

– To set labels, values (for simple components) & models (for complex components), select component and choose Circuit/Component Properties, choose desired tab, make any changes, and click OK.

– Can also invoke Circuit/Component Properties box by double-clicking on component.

***** *Notes:*

The Circuit/Component Properties box contains a number of tabs; depending on which component is selected an analog component has either a value or a model, not both.

Wiring Components

– Point to a component's terminal so it highlights; press & hold mouse button, and drag so a wire appears drag wire to a terminal on another component or to an instrument connection, when terminal on second component or instrument highlights, release mouse button

Inserting, Connecting, Editing

Inserting Components

– To insert component into existing circuit, place it on top of wire; it will automatically be inserted if there is room.

Connecting Wires

– If drag a wire from a component's terminal to another wire, a **connector** is automatically created when

you release mouse button.

– Note: a connector button also appears in the Basic toolbar (to insert connectors into an existing circuit).

Deleting Wires

– To delete a wire, select it & choose Edit/Delete

– Alternatively, disconnect wire by selecting one end of it & moving it to an open spot on circuit window.

Changing Wire Color

– To change a wire's color, double-click it & choose Schematic Options tab; click the Color button & choose a new color.

Straightening a Wire

– move wire itself.

– move component to which wire is attached.

– press ALT and move component to which wire is attached.

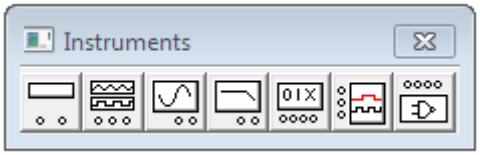
– select component and press appropriate arrow key to align it.

– If two wires cross in a way that makes them hard to follow, select one & drag it to new location

**Note*:

- the way a wire is routed sometimes depends on terminal from which wire was dragged; try disconnecting routed wire & then rewire from the opposite terminal.

Instruments



– *Using an Instrument Icon*

To display the Instruments toolbar, click the Instruments button on the Parts Bin toolbar.

To place an instrument on the circuit window, drag the desired button from the Instruments toolbar to the window. To attach an instrument to a circuit, point to a terminal on its icon so it highlights and drag a wire to a component. To remove an instrument icon, select it & choose Edit/Delete

– *Opening an Instrument*

Double-click the instrument's icon to see its controls

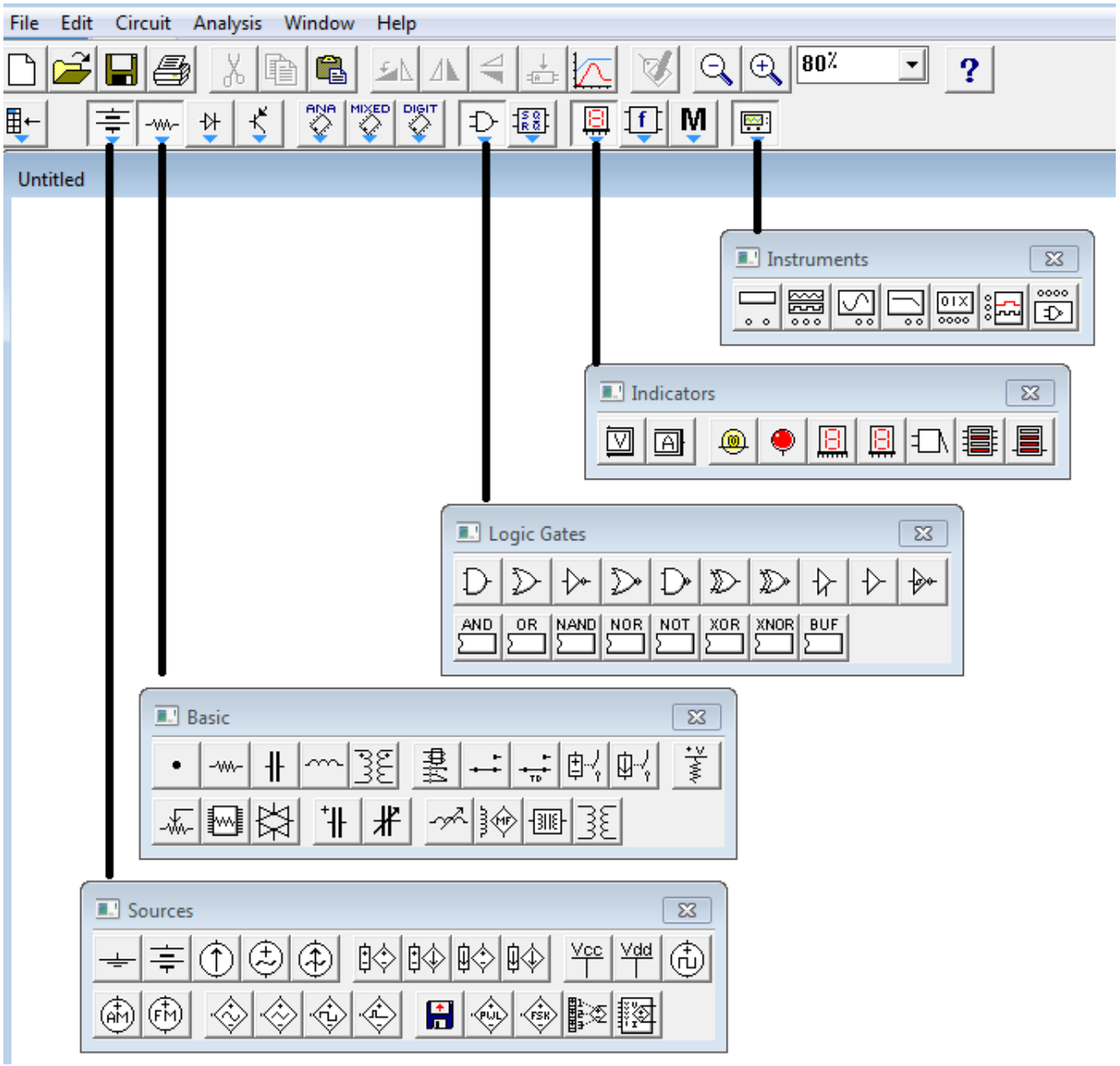
- To selection options, click buttons on the controls
- To change values or units, click the up/down arrows.

Simulation

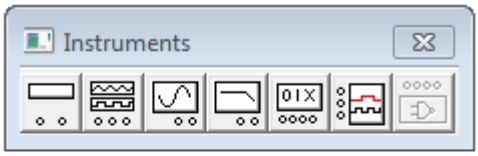
Click the power switch to turn power on. Click switch again to turn power off. (Note: Turning off power erases data & instrument traces.

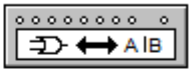
Lab Tasks

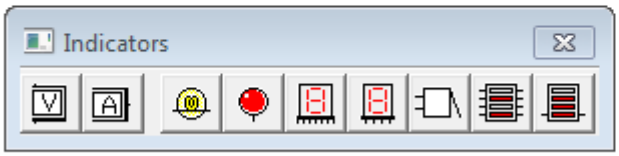
Task 1: Name the basic toolboxes of EWB

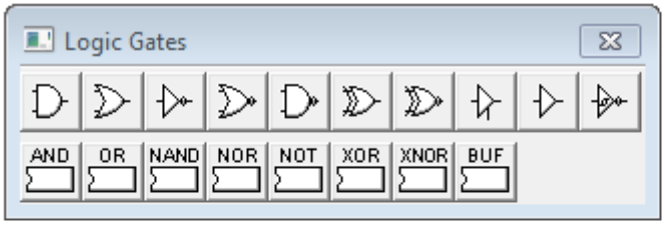


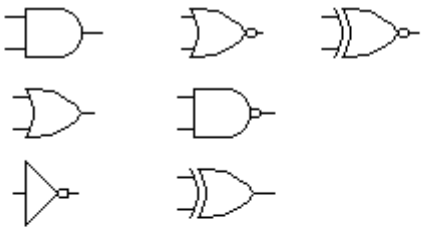
Task 2: Basic buttons in EWB toolboxes

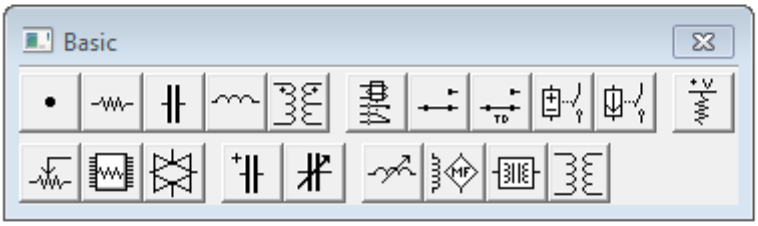


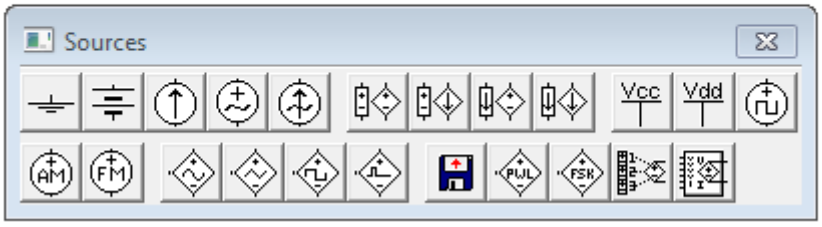




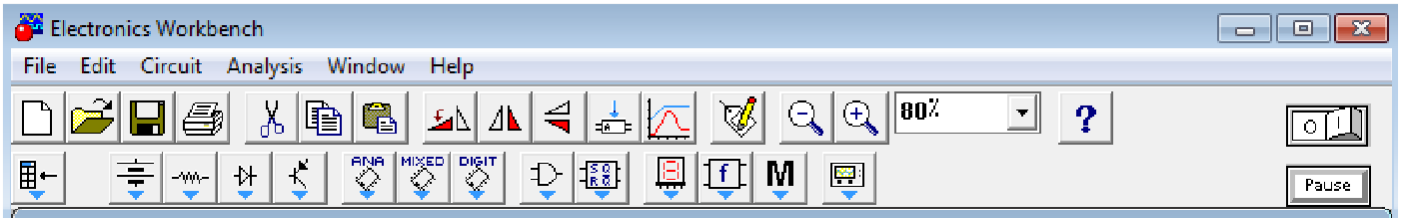






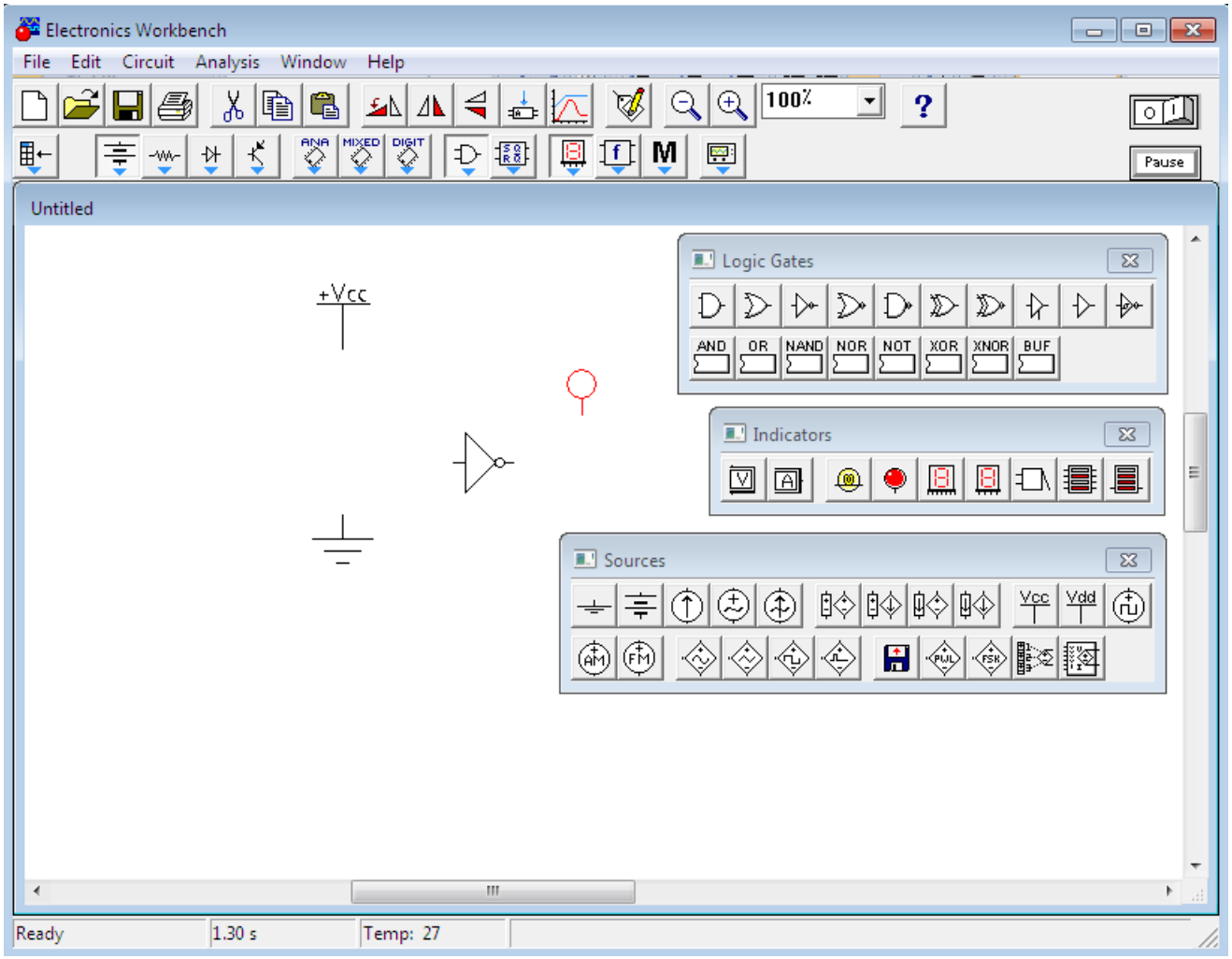


Task 3 EWB Toolbar



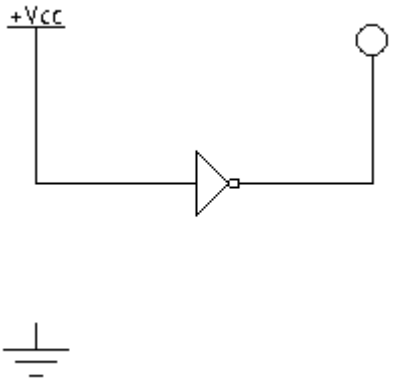
Task 4: Simple circuit; playing with EWB

In the following circuit

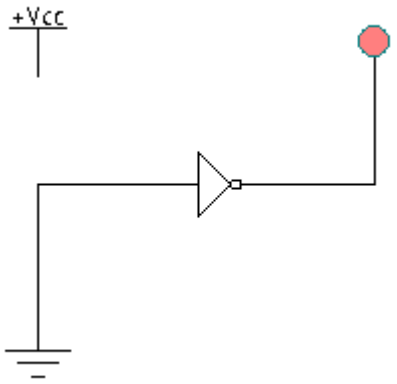


Draw the following circuit. After that make the following changes

- Connect the output of the converter to the red probe
- Connect the Vcc line to the input of the inverter
- Start simulating the circuit State your observation down: **Observation**:



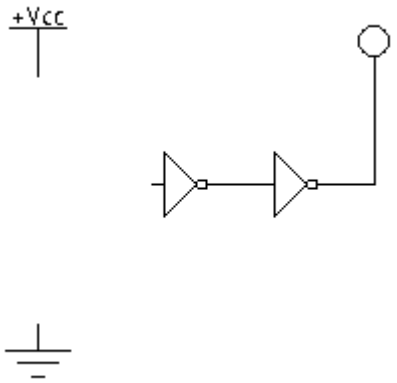
- In the same circuit above, stop the simulation and connect the ground to the input of the inverter. State your observation down:



Observation:

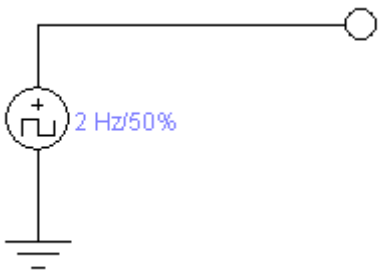
Task 5: Simple circuit; two inverters connected serially

Repeat Task 2 of this report and state down your observations.

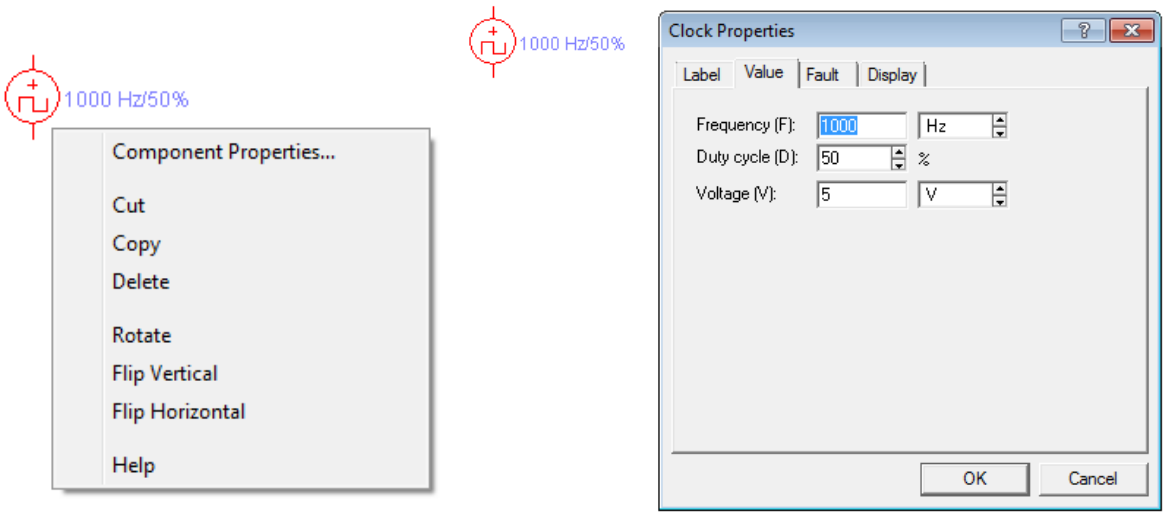


Task 6: Simple circuit; a clock source with a red probe

Draw the following circuit and simulate it. Write down your observations. Notice that the **clock** (from *Sources* toolbox) frequency is 2 Hz.

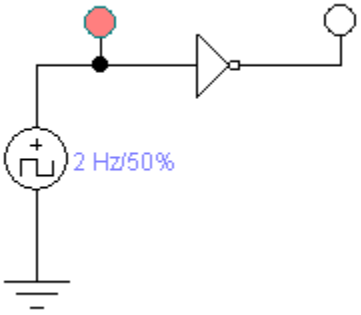


Note: You can change the default values of the clock by doing mouse right clicking on the clock and click on the "Component Properties ..." as shown below:



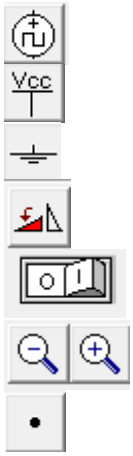
Task 7: Simple circuit; a clock source with two red probes

Draw the following circuit and simulate it. Write down your observations. Notice that the clock frequency is 2 Hz.



Task 8: EWB Menu

Name the following icons and state down their functions



Lab Experiment # 02

Basic logic Gates (AND, OR, and NOT gates)

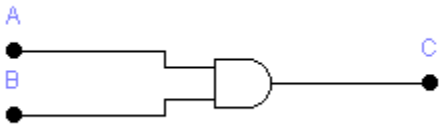
Objectives

1- To study and understand the 3 basic gates.
2- Implement the basic gate in EWB.
3- The study the specifications of every gate when connected it with one input constant and the other is variable.

AND and NAND gates

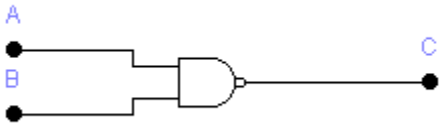
This gate gives high output (1) if all the inputs are 1's. otherwise the output will be low (0).

Its Boolean algebra representation is: C=A.B
And its truth table and schema as following:



A	B	C
0	0	0
0	1	0
1	0	0
1	1	1

The NAND gate works opposite to the AND gate. Its Boolean algebra representation is: C= (A.B)'
And it's truth table and schema as following:

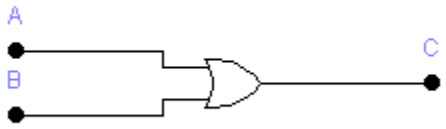


A	B	C
0	0	1
0	1	1
1	0	1
1	1	0

OR and NOR gates

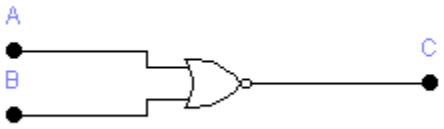
This circuit will give high output (1) if any input is high (1).

Its Boolean algebra representation is: C=A+B and its truth table and schema as following:



A	B	C
0	0	0
0	1	1
1	0	1
1	1	1

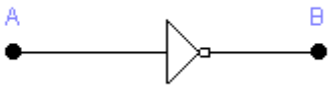
The NOR gate works opposite to the OR gate. Its Boolean algebra representation is: C=(A+B)'
And it's truth table and schema as following:



A	B	C
0	0	1
0	1	0
1	0	0
1	1	0

NOT gate

This is the simplest gate it just inverts the input, if the input is high the output will be low and conversely.
So, B =A'

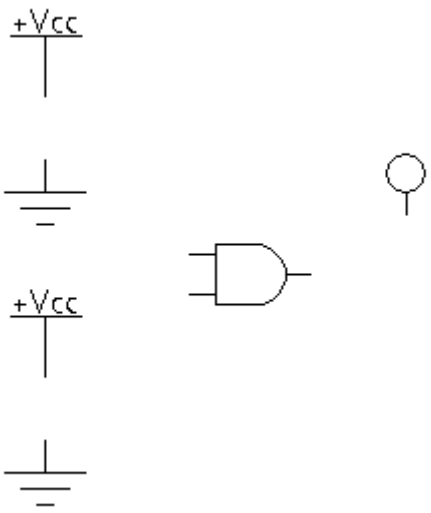


A	B
0	1
1	0

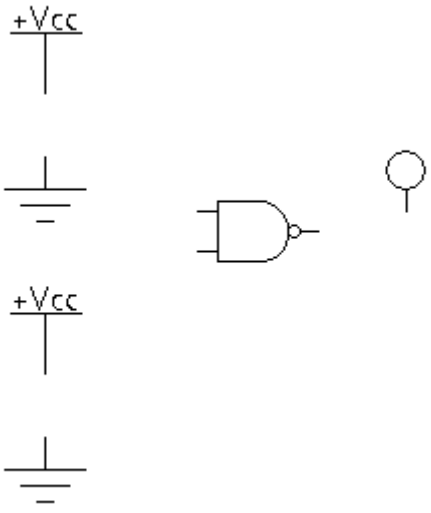
Lab Tasks

Task 1: The AND and NAND gates

In EWB, draw the following two circuits and fill the truth table below

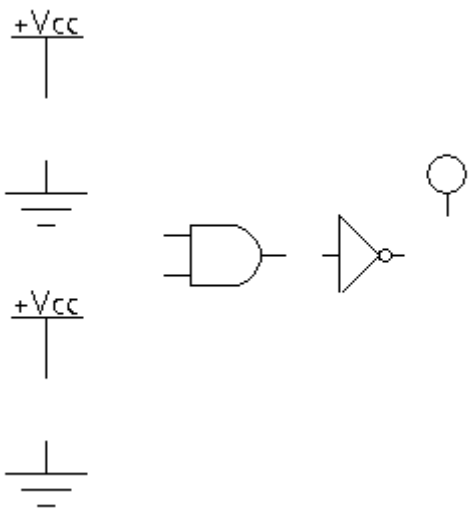


A	B	A.B	(A.B)’
0	0		
0	1		
1	0		
1	1		



Task 2: The AND-NOT combination

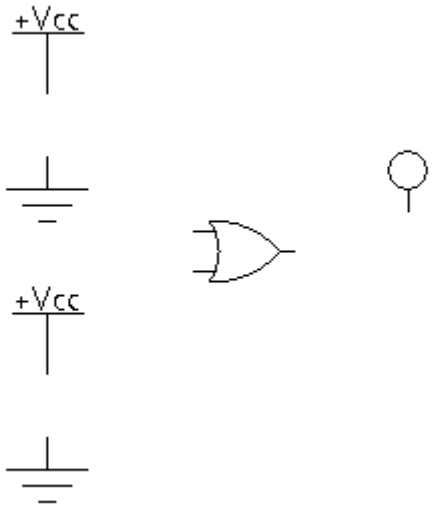
In EWB, draw the following circuit and fill the truth table

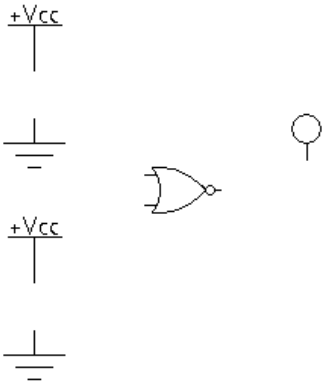


A	B	(A.B)’
0	0	
0	1	
1	0	
1	1	

Task 3: The OR and NOR gates

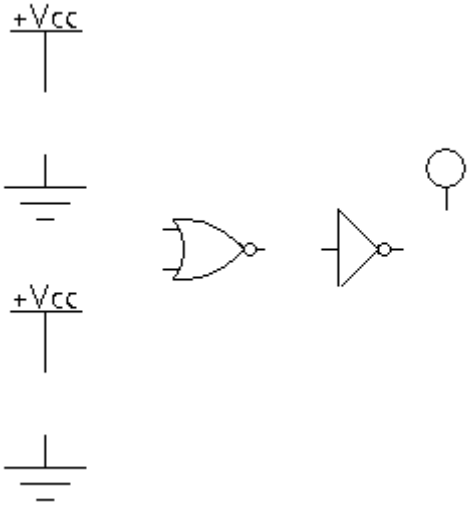
In EWB, draw the following two circuits and fill the truth table below





A	B	A+B	(A+B)’
0	0		
0	1		
1	0		
1	1		

Task 4: The NOR-NOT combination



A	B	((A+B)')'
0	0	
0	1	
1	0	
1	1	

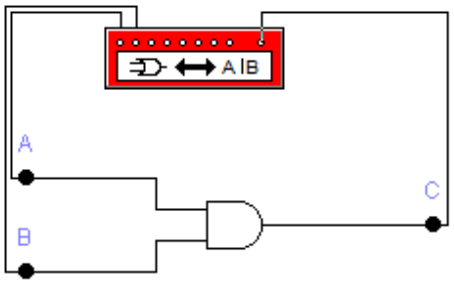
Task 5: Finding the truth table of a gate using the logic converter

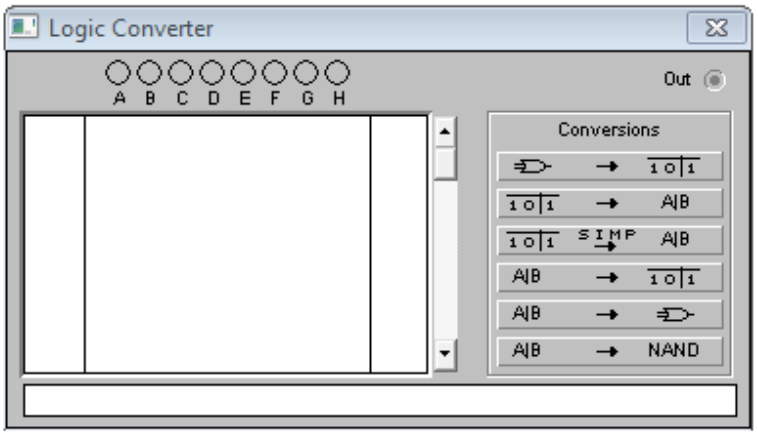
The logic converter can be found in the *Instruments* toolbox. It can be used to derive a truth table from a circuit schematic:

1. Attach the input terminals of the logic converter to up to eight input points in the circuit.
2. Connect the single output of the circuit to the output terminal on the logic converter icon.
3. Click the Circuit to Truth Table  button.

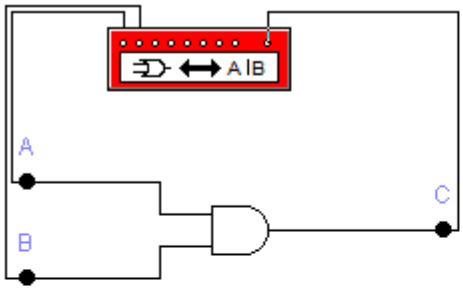
The truth table for the circuit appears in the logic converter's display.

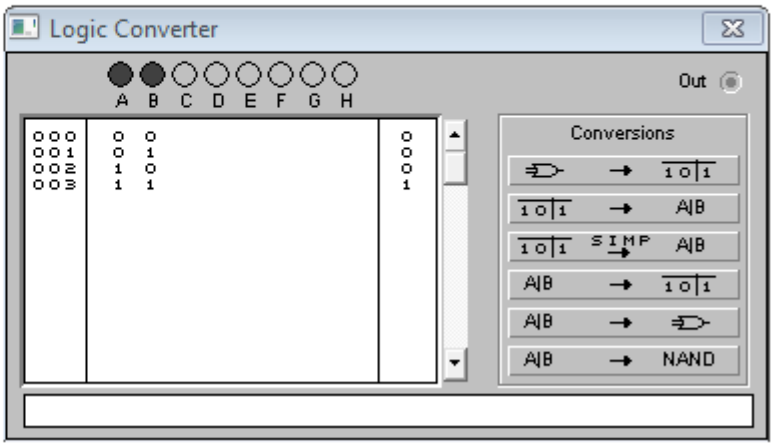
In the following circuit, we will be examining the AND gate. The two inputs of the gate are attached the A and B inputs of the logic converter. The circuit output C is connected to *Outl*ine of the logic converter.





After clicking on the Truth Table button of the logic converter, the logic converter tries all possible combinations of the circuit input and derives its truth table.

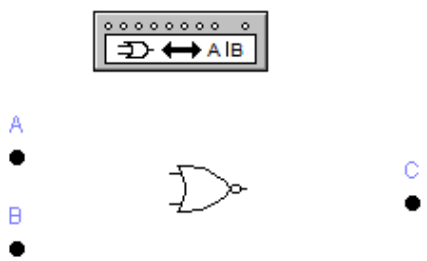


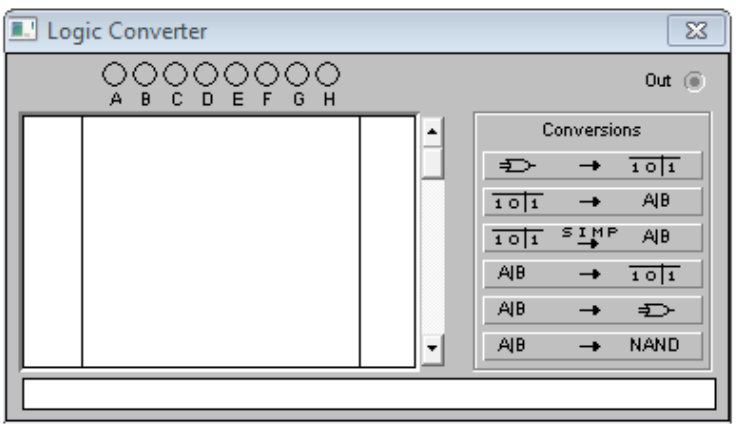


Task 6: Finding the truth table of a gate using the logic converter

Repeat what you did in task 5 for the NOR gate. Show your connections in the circuit below.

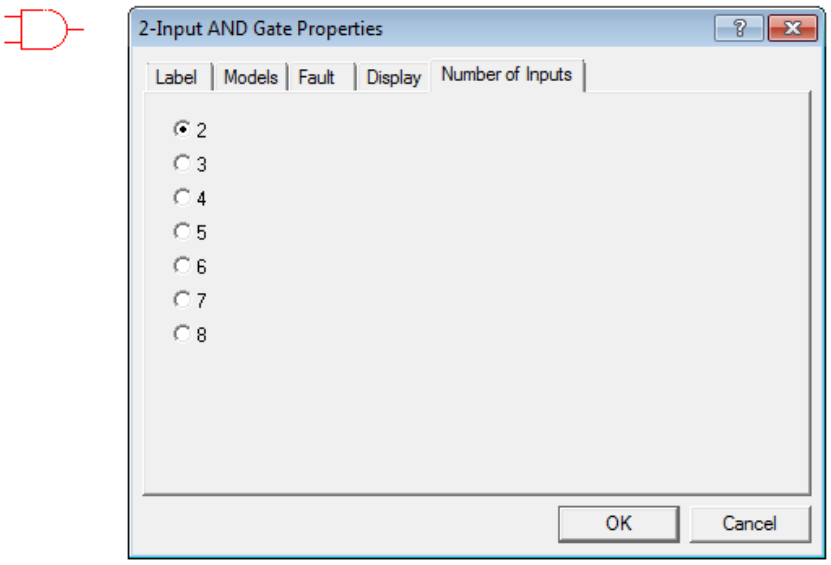
A	B	A+B	(A+B)'
0	0		
0	1		
1	0		
1	1		

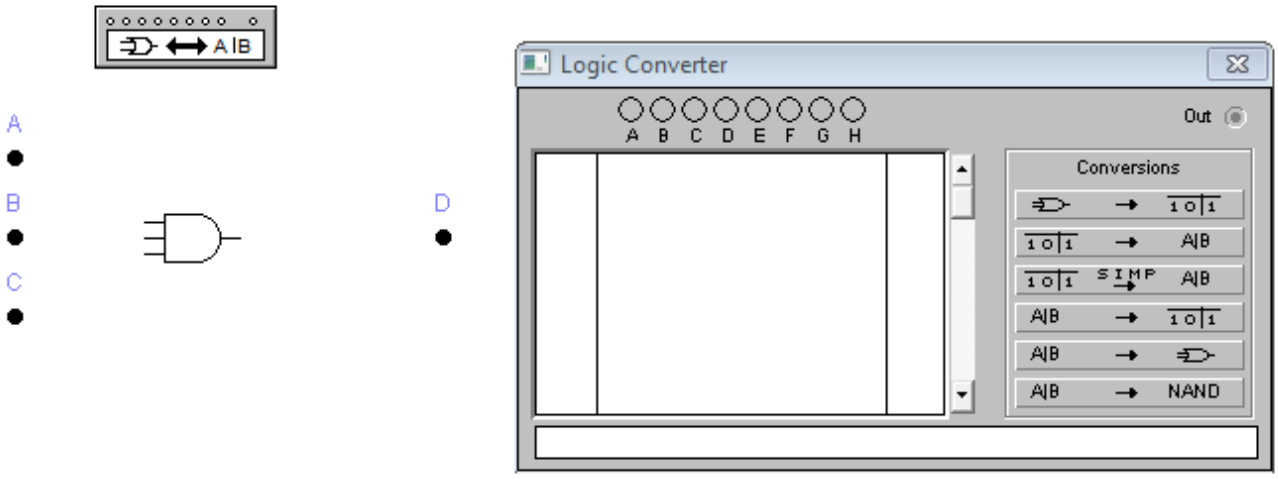




Task 7: Finding the truth table of a three-input gate using the logic converter

Repeat what you did in task 5 for a three-input AND gate. Show your connections in the circuit below.
Note: you can obtain a three-input AND gate by drawing a regular two-input AND gate and then changing its *Number of Inputs* property as shown next.

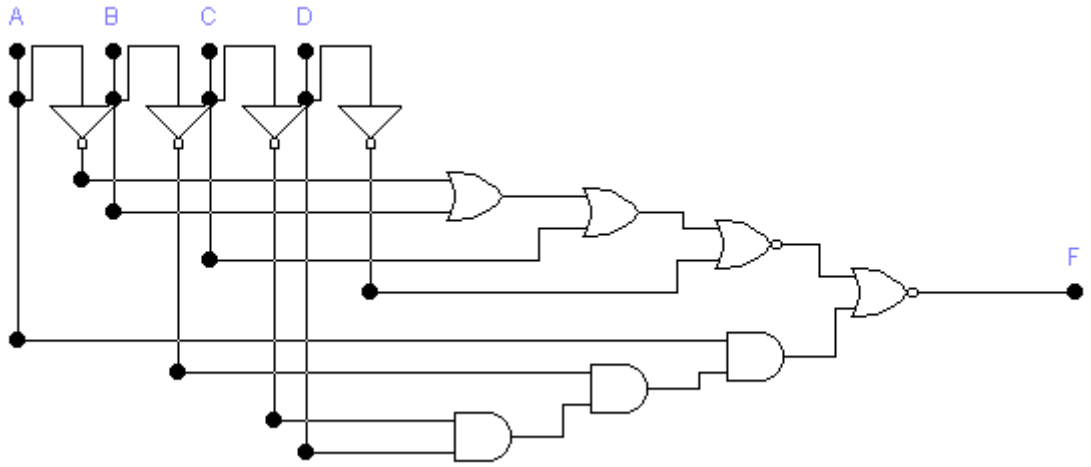




A	B	C	D
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

Task 8: Finding the truth table of a given circuit using the logic converter

Find the truth table of the following circuit:



A	B	C	D	F
0	0	0	0	
0	0	0	1	
0	0	1	0	
0	0	1	1	
0	1	0	0	
0	1	0	1	
0	1	1	0	
0	1	1	1	
1	0	0	0	
1	0	0	1	
1	0	1	0	
1	0	1	1	
1	1	0	0	
1	1	0	1	
1	1	1	0	
1	1	1	1	

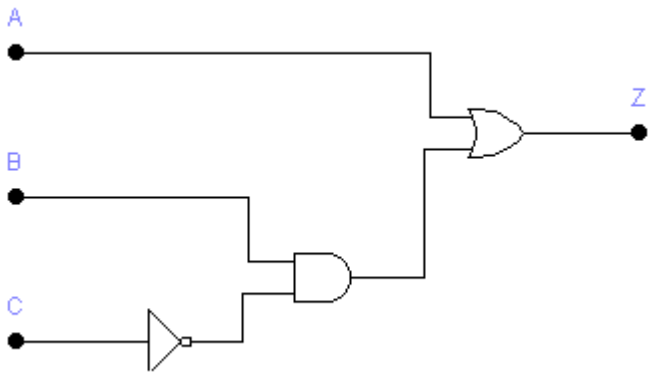
Lab Experiment # 03

Digital logic circuits analysis and converting Boolean expressions to digital circuits

Objectives

- To learn how to directly convert a Boolean expression to circuit.
- To learn how to analyze a given digital logic circuit by finding the Boolean expression that represents the circuit
- To learn how to analyze a given digital logic circuit by finding the truth table that represents the circuit.

Example:
Z = A + B . C'
The above function is implemented in the following digital logic Circuit



Now after drawing the circuit above using EWB we find that its truth table is as shown below (notice that logic 1 means connect the input to the Vcc line, and logic 0 means connecting the input to the ground)

A	B	C	Z
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

Lab Tasks

Task 1: Converting Boolean expressions into circuits

Convert the following Boolean expression to a circuit, draw the circuit on EWB and simulate it to fill-in its truth table shown below.
X = Y + Z. Y'

Draw the circuit in the space below

Now, fill-in the truth table of the circuit you drawn

Y	Z	X
0	0	
0	1	
1	0	
1	1	

Task 2: Converting Boolean expressions into circuits

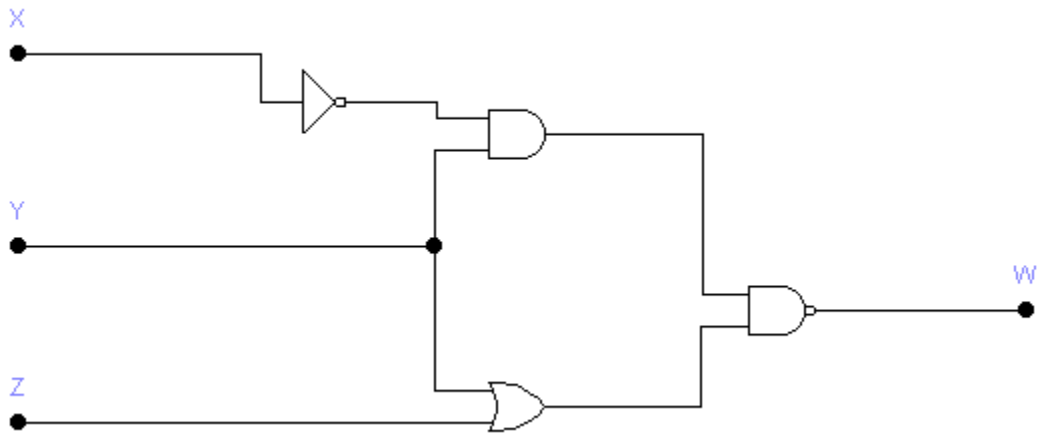
Convert the following Boolean expression to a circuit, draw the circuit on EWB and simulate it to fill-in its truth table shown below.
D = (A. B) + (C'. A)

A	B	C	D
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

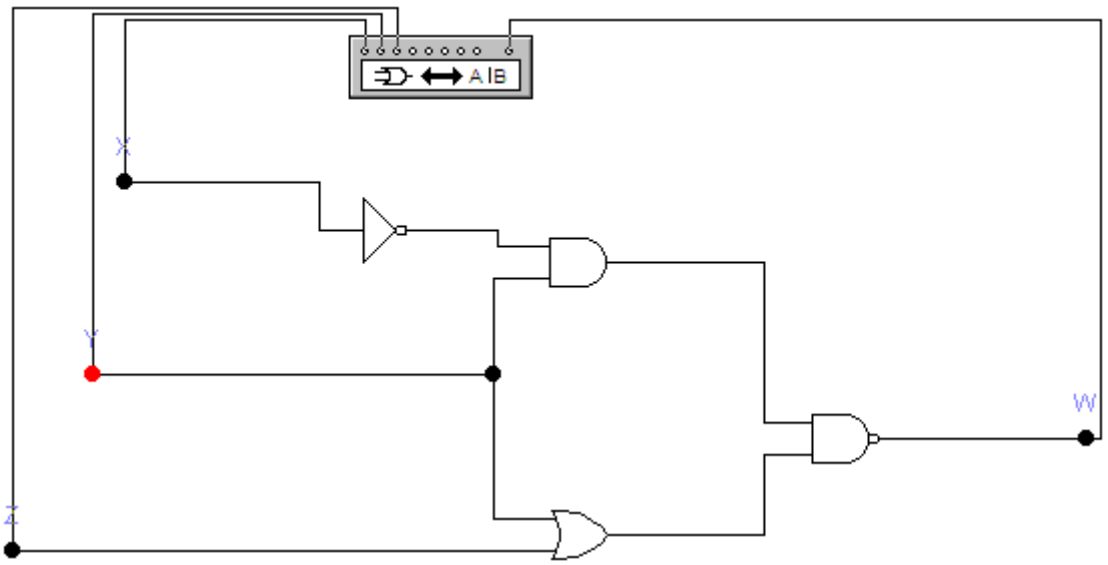
Task 3: Digital logic circuit analysis – Finding the Boolean expression of a given circuit

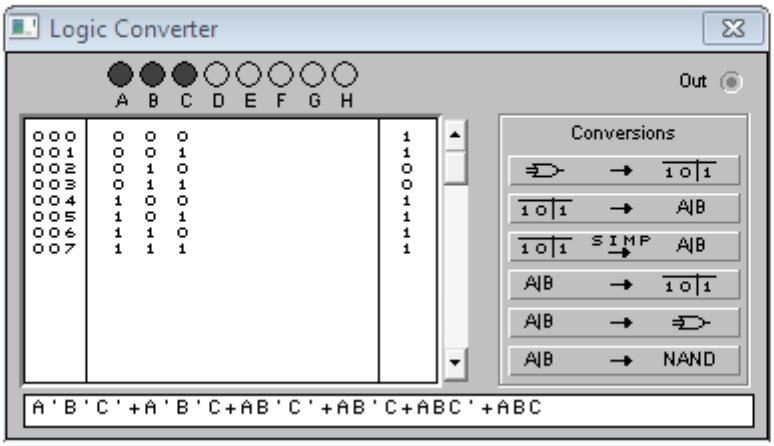
Find the Boolean expression of the following circuit, draw the circuit on EWB and simulate it to fill-in its truth table shown below.

W =



Note: the logic converter tool from EWB to fill-in the following table. For that, you need to connect the A, B and C inputs of the logic converter to X, Y and Z lines, respectively. Further, you need to connect the 'out' line of the logic converter to W. As shown in the following diagram



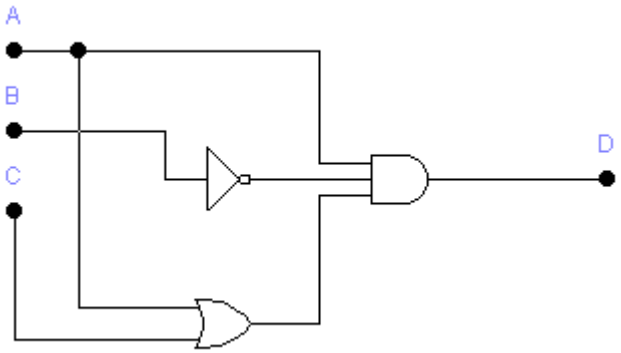


X	Y	Z	W
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

Task 4: Digital logic circuit analysis – Finding the Boolean expression of a given circuit

Find the Boolean expression of the following circuit,

D =



Draw the circuit on EWB and simulate it to fill-in its truth table shown below (*use logic converter please*).

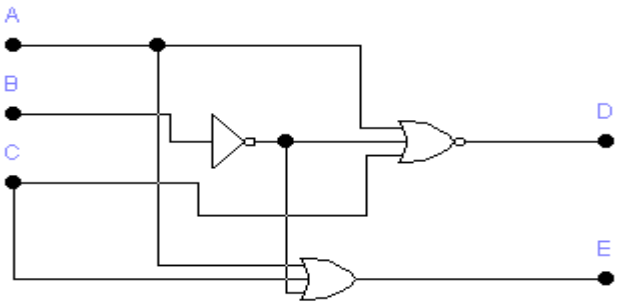
A	B	C	D
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

Task 5: Logic circuits with multiple outputs

Find the Boolean expression of the outputs of the following circuit,

D =

E =



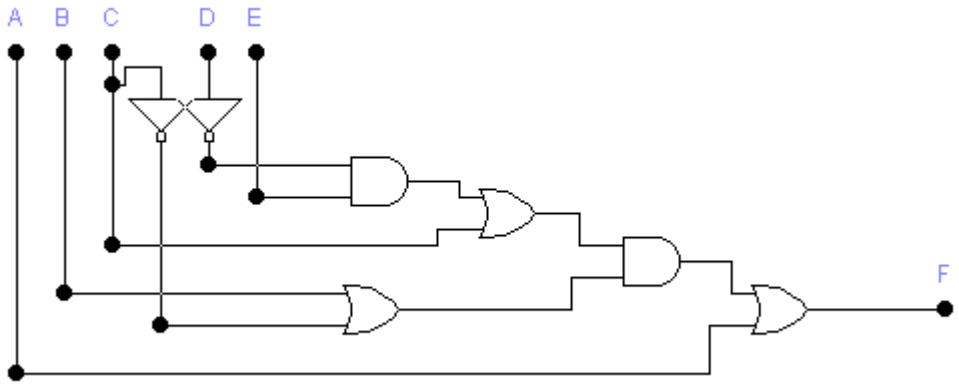
Draw the circuit on EWB and simulate it to fill-in its truth table shown below (*use logic converter please*).

Note: You need to use the logic converter two times, once for the output D, and another time for the second output E.

A	B	C	D	E
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

Task 6*: Finding the Boolean expression of a given circuit using the logic converter

Draw the following circuit on EWB and then find its Boolean expression using the logic converter.



Task 7*: Converting Boolean expressions to circuits using the logic converter

Use the logic converter to realize the following circuit using suitable logic gates:
AB'C (BD + CDE) + AC'