



The Islamic University of Gaza

Faculty of Engineering

Department of Computer Engineering

Digital Electronics LAB

[LAB 02]

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Objectives

- To be familiar with the operation of diode-resistor logic-circuits.
- To determine VTC of these gates.

Theory

1) Diode-resistor logic (DRL):

The Diode-resistor logic circuits consist of **diodes and resistor only**.

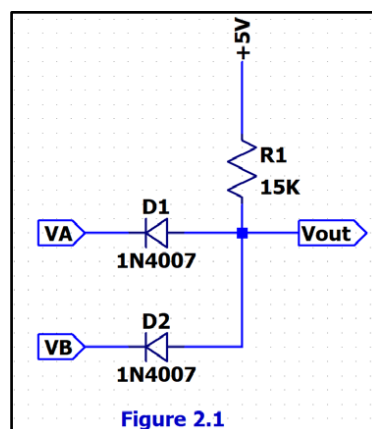
The logic functions available are:

1. AND Gate.
2. OR Gate.
3. Level-shifted AND Gate.
4. Level-shifted OR Gate.

- **AND Gate.**

This circuit consists of a resistor connected directly to the VCC supply, which then feeds two reverse-biased diodes (reverse with respect to the input). Thus, for the output to equal VCC, both diodes must be in cutoff state.

However, if one of the diodes is active (conducting), it provides a current path through the conducting diode, causing the output to equal the voltage drop across that diode.



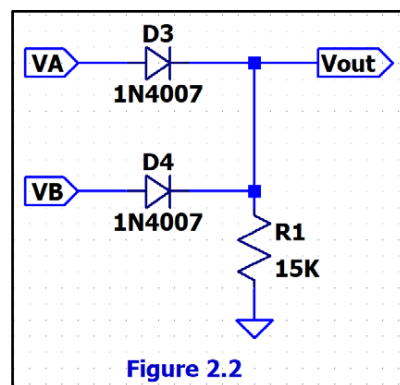
Here's the truth table with the added sentence.

V_A	V_B	V_{OUT}
0	0	0
1	0	0
0	1	0
1	1	1

Therefore, when either $V_A = 0$ or $V_B = 0$ (but not both), V_{OUT} will equal $V_D + V_{in}$. However, when both $V_A = 0$ and $V_B = 0$ simultaneously, V_{OUT} will equal V_{CC} .

• OR Gate.

As you can see, in the circuit at hand, the resistor has essentially become a pull-down resistor, and V_{out} is connected to the resistor. There are also two forward-biased diodes connected through the resistor. Regarding the output, what will its shape be? It will depend on the present input: if any one of these inputs is at a high level, it will propagate to the output regardless of the state of the other input.



V_A	V_B	V_{OUT}
0	0	0
1	0	1
0	1	1
1	1	1

The mathematical expression for this circuit is relatively simple: if any of the inputs is at a logic-high level, the output will reflect this state, independent of the other input conditions.

$$V_{out} = V_{in} - V_D$$

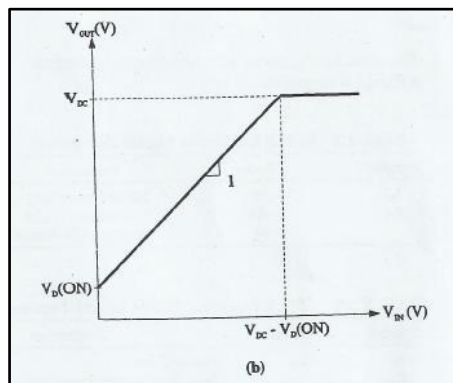
Accordingly, if the input voltage is 5 V, the equation will be as follows:

$$V_{out} = 5 - 0.7 = 4.3 \text{ V}$$

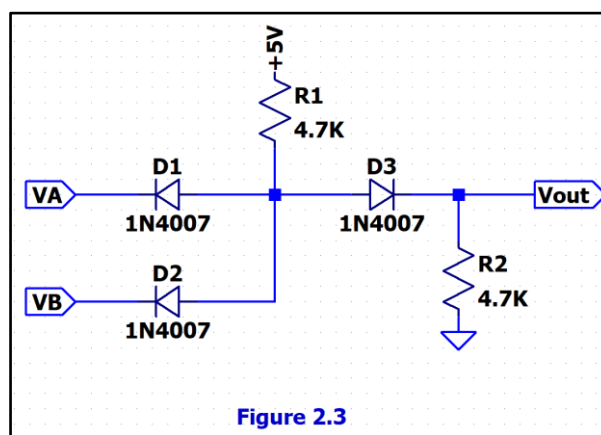
On the other hand, when the two diodes are in cutoff mode, V_{out} will be equal to zero.

• Level-Shifted AND Gate.

Before addressing this circuit, it is necessary to first examine the schematic diagram of the AND gate circuit, which is as follows:



As you can see, the plot for the circuit does not start at the origin; rather, it begins at 0.7 V on the vertical axis. By using level shifting we try to make the output voltage equal to zero. How is this achieved? By wiring the resistor as shown in the circuit at hand: the resistor is used as a pull-down, and a forward-biased diode is connected.



As for the equations, when the input is low, the expression will be:

$$V_{out} = V_{in} + V_{D1} - V_{D3} = V_{in}$$

If V_{in} for V_A or V_B is less than $-V_{ee}$, the diodes $D1$ and $D2$ are off, and

$$V_{out} = -V_{ee} = V_{oL}$$

If both inputs are high:

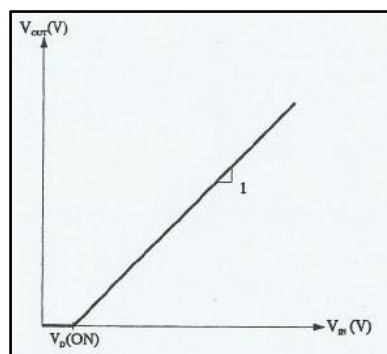
$$V_{out} = V_{OH}$$

$$I_D = (V_{CC} + V_{EE} - V_{D3}) / (R_1 + R_2)$$

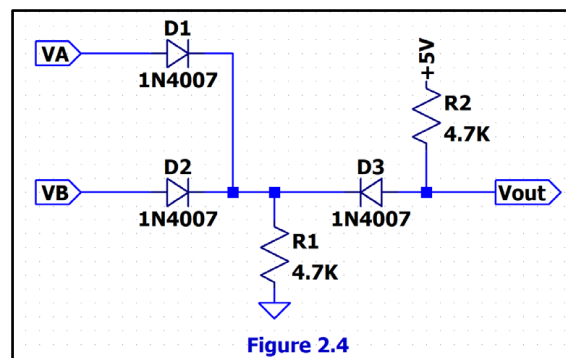
$$V_{OH} = -V_{EE} + I_D \cdot R_2$$

- **Level-Shifted OR Gate.**

Before examining this circuit, it is essential to first look at the schematic diagram of the OR gate circuit, which is as follows:



As you can see, the plot for the circuit does not start at the origin; rather, it begins at 0.7 V on the x-axis. By performing a level shift we try to make the voltage equal to zero. How is this accomplished? By adding a resistor and a diode, as shown in the circuit at hand.

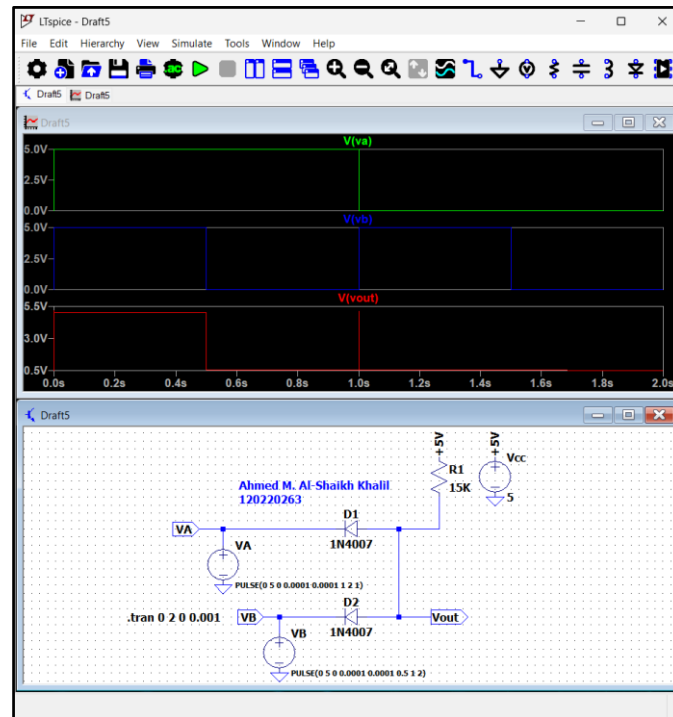


These are the equations for the level-shifted OR gate:

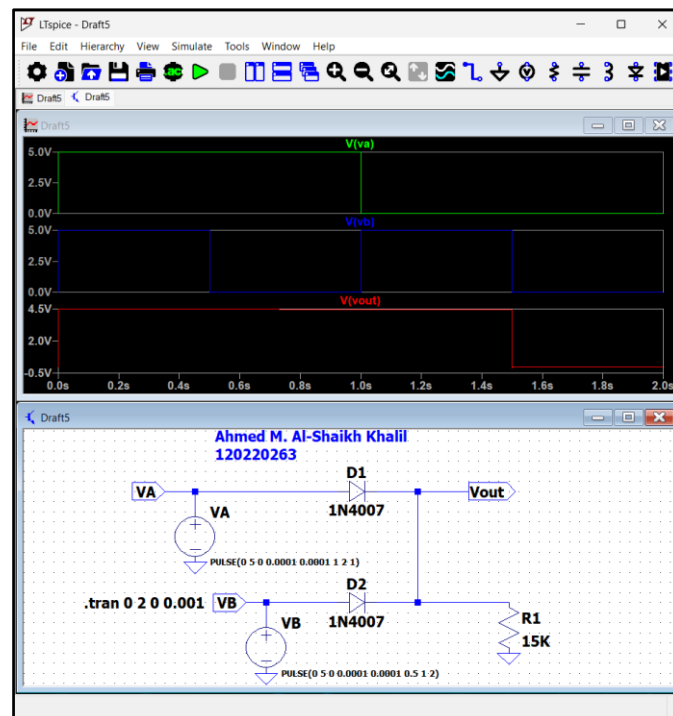
- If all inputs are low, the diodes off,
 $I_D = (V_{CC} + V_{EE} - V_{D3}) / (R_1 + R_2)$
 $V_{OL} = V_{CC} - I_D \cdot R_2$
- If either input is high, the corresponding diode is conducting then
 $V_O = V_{OH} = V_{in} - V_{D2} + V_{D3} = V_{in}.$

Experimental Procedure & Report tasks:

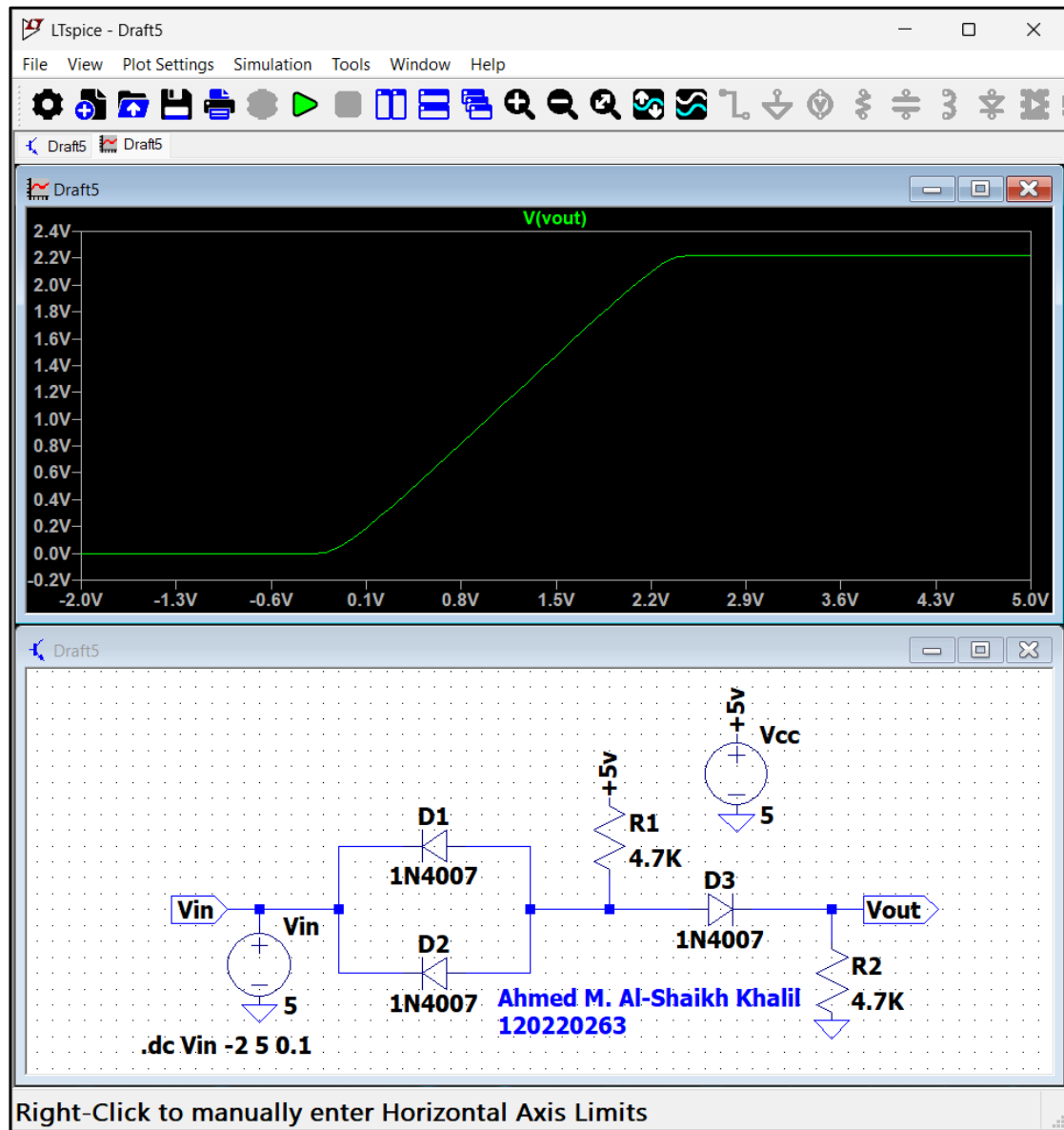
Part (1): AND Gate Truth table:



Part (2): OR Gate Truth table:



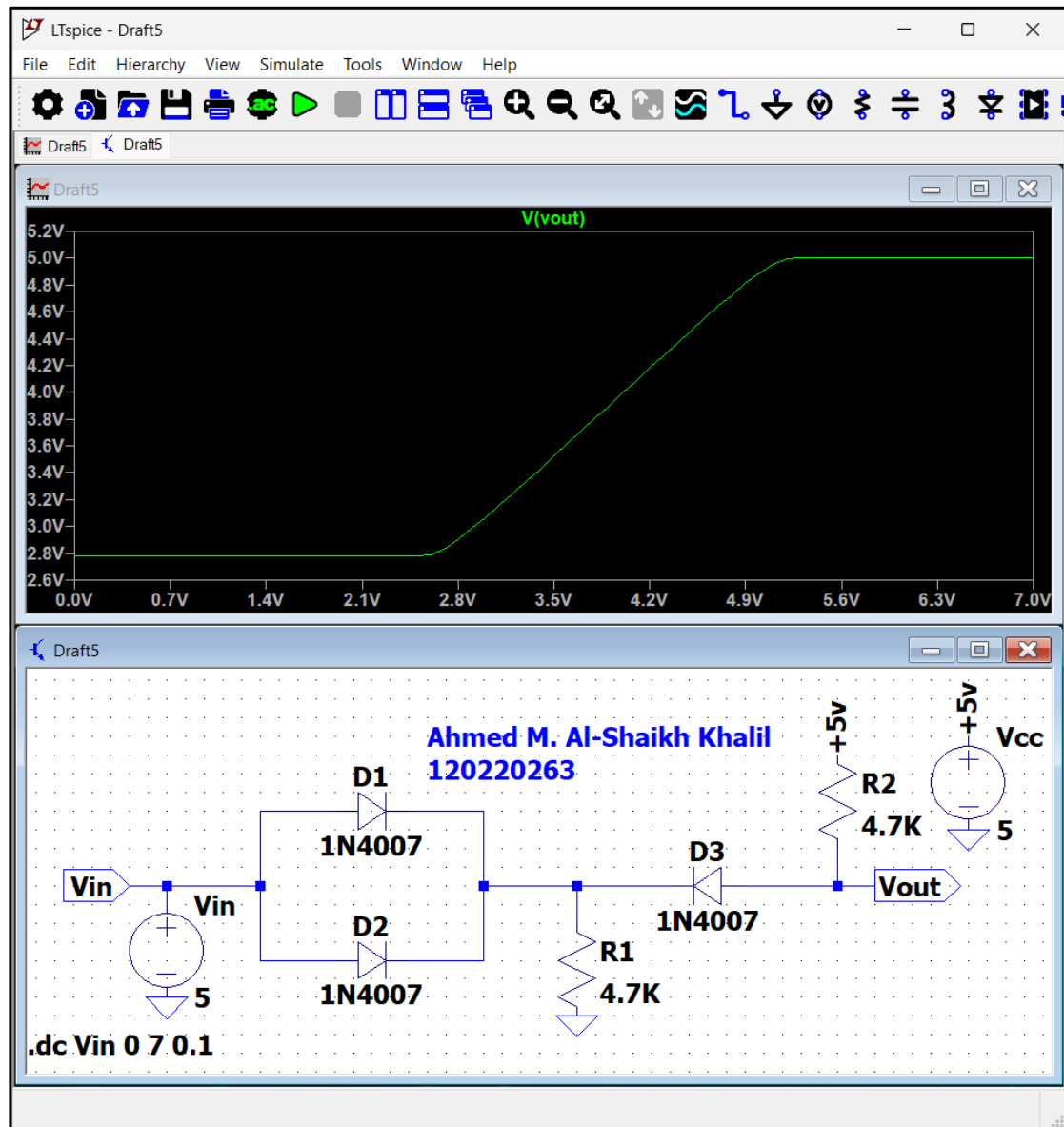
Part (3): Level-Shifted AND Gate VTC:



$$V_{oH} = 2.2198391V$$

$$V_{oL} = -429.7035nV$$

Part (4): Level-Shifted AND Gate VTC:



$$V_{oH} = 5.0000005V$$

$$V_{oL} = 2.7801609V$$