KAZAKH BRITISH TECHNICAL UNIVERSITY

School of Information Technology and Engineering

# Laboratory work 2
# REALIZATION OF LOGIC GATES WITH TRANSISTORS

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Almaty 2024

**Aims:**
define what logic gates are realized schematically, learn the gates' properties. Compare the experimental results with theoretical foundations about logic gates. Improve skills of the schemes' preparation.

## Practice task:
## Preparation to lab work

1. Learn the information about transistors
2. Show bipolar transistors' characteristics
3. Consider experiments schemes' and draw them with application of Scheme od Design System. Analyze what gates are realized on the shemes' basis. Fill in the basis theoretically.
4. Answer the questions below in written form.

4.1 What is a bipolar transistor?
4.2 What are names ofa bipolar transistor's electrodes?
4.3 How to define situation of a bipolar transistor's electrodes?
4.4 What are conditions to have a bipolar transistor ON(OFF)?
4.5 What types of bipolar transistors do you know?
4.6 What are typical silicon transistor's parameters?
4.7 What modes of a bipolar transistor's operation do you know?

## Answers to Questions

1. **What is a bipolar transistor?**
   A bipolar transistor is a type of transistor that uses both electron and hole charge carriers. It consists of three regions of doped semiconductor material: the emitter, the base, and the collector.
2. **What are the names of a bipolar transistor's electrodes?**
   The electrodes of a bipolar transistor are called the emitter, the base, and the collector.
3. **How to define the situation of a bipolar transistor's electrodes?**
   The situation of a bipolar transistor's electrodes can be defined by measuring the voltages and currents at each electrode terminal.

Additionally, the biasing arrangement (whether the transistor is in forward or reverse bias) determines the operation mode of the transistor.

4. **What are the conditions to have a bipolar transistor ON(OFF)?**
   To turn a bipolar transistor ON, a forward bias voltage must be applied between the base and emitter terminals, allowing current to flow from the emitter to the collector. To turn it OFF, a reverse bias voltage is applied between the base and emitter, preventing significant current flow.

5. **What types of bipolar transistors do you know?**
   There are two main types of bipolar transistors: NPN (Negative-Positive-Negative) and PNP (Positive-Negative-Positive). These types differ in the doping of the semiconductor regions.

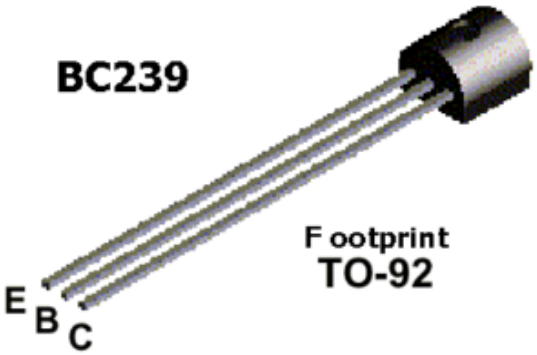
6. **What are typical silicon transistor's parameters?**
   Typical parameters of a silicon transistor include maximum collector current (IC), maximum collector-emitter voltage (VCE), current gain (hFE), transition frequency (fT), and maximum power dissipation (Pd).

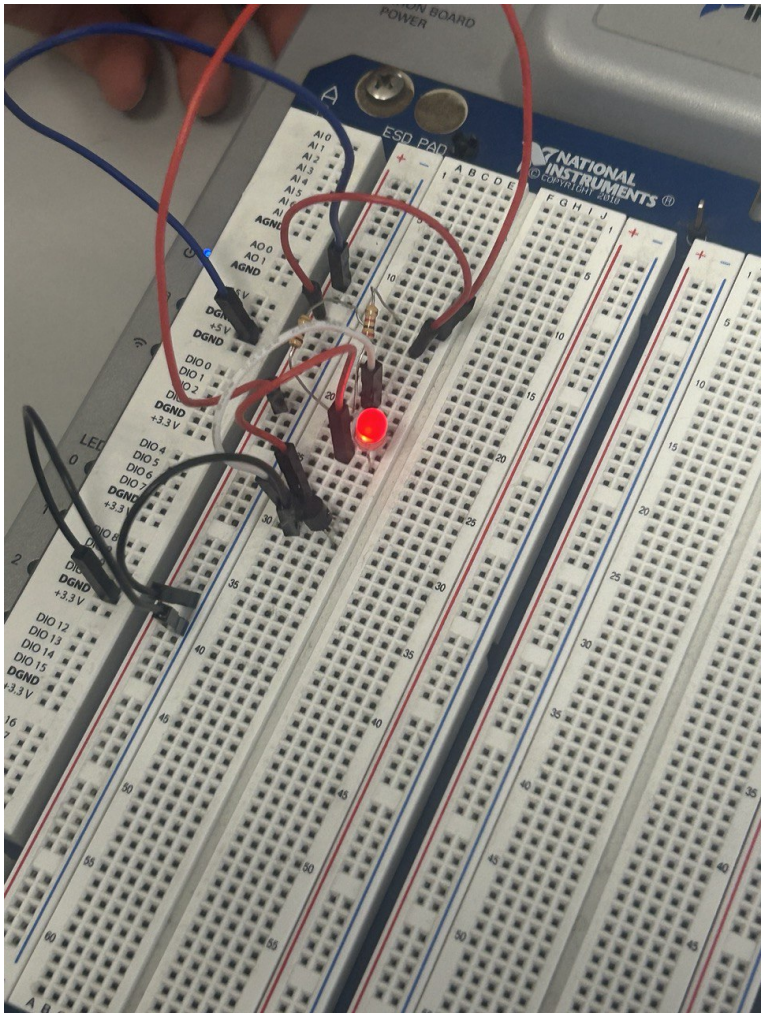
7. **What modes of a bipolar transistor's operation do you know?**
   The main modes of operation for a bipolar transistor are:

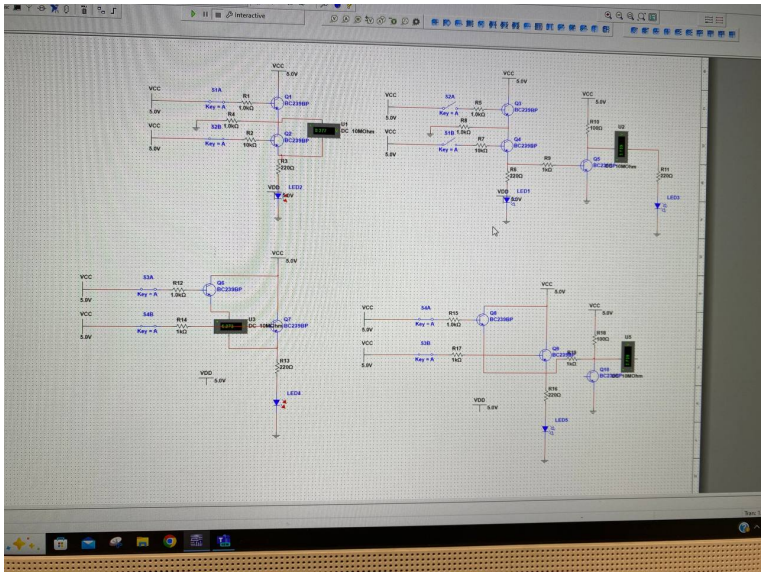
   - Active mode: The transistor operates as an amplifier, with both base-emitter and base-collector junctions forward-biased.
   - Cut-off mode: The transistor is OFF, with both junctions reverse-biased.
   - Saturation mode: The transistor is fully ON, with both junctions forward-biased and maximum collector current flowing.

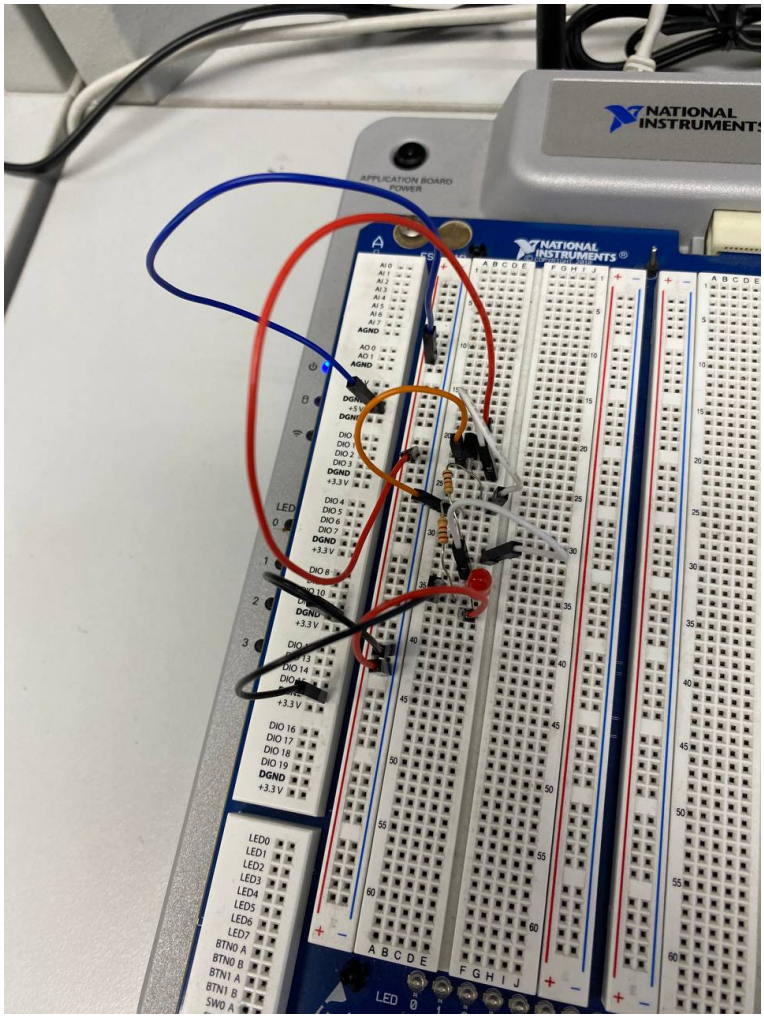
# LAB WORK PERFORMANCE

1. Demonstrate presence of your home preparation for lab work to your instructor.
2. Pass test of 10 questions.
3. Get a permission to begin the work.
4. Mount the first scheme of experiment 2 on the breadboard and perform it.
5. Make a conclusion about functionality of the scheme. Compare your results with theoretical ones.
6. Demonstrate your results to your instructor. If your results are correct you may dismount your scheme, if no – find the mistake.
7. Repeat steps 4 to 6 for the second and third schemes of experiment 2.
8. Be ready to answer your instructor's questions in process of work.
9. Complete your work, dismount your schemes, clean your working place.
10. Answer your instructor's final questions, obtain your mark.
11. Ask your instructor's permission to leave.






NATIONAL INSTRUMENTS
APPLICATION BOARD POWER
AGND
DGND
+3.3 V
DIO 16
DIO 17
DIO 18
DIO 19
LED0
LED1
LED2
LED3
LED4
LED5
LED6
LED7
BTN0 A
BTN0 B
BTN1 A
BTN1 B
SW0 A

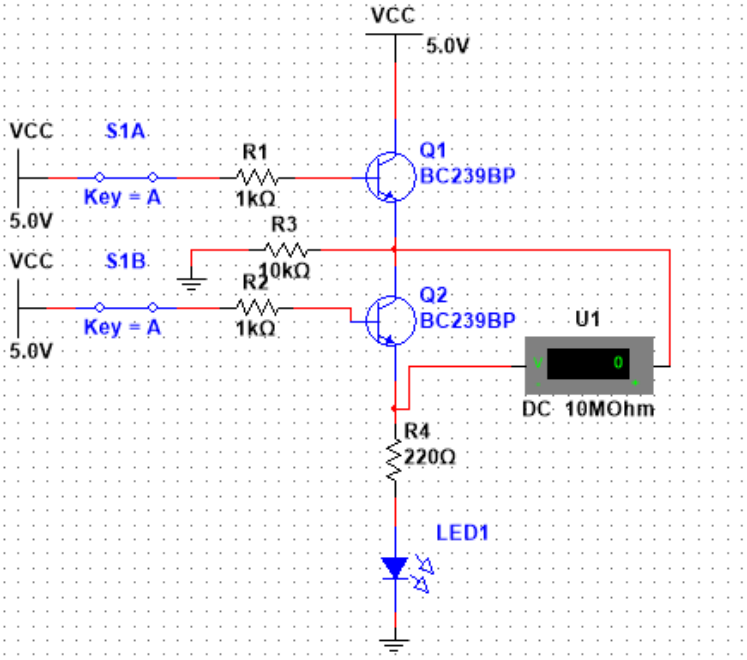



Table 1: AND

| | Input | Input | Output | Output |
|---|---|---|---|---|
| | A | B | LED | $V_out$ |
| 1 | 0v | 0v | 0v | 1.777nv |
| 2 | 0v | 5v | 0v | -6.704 |
| 3 | 5v | 0v | 0v | 3.066v |
| 4 | 5v | 5v | 5v | 0.278v |

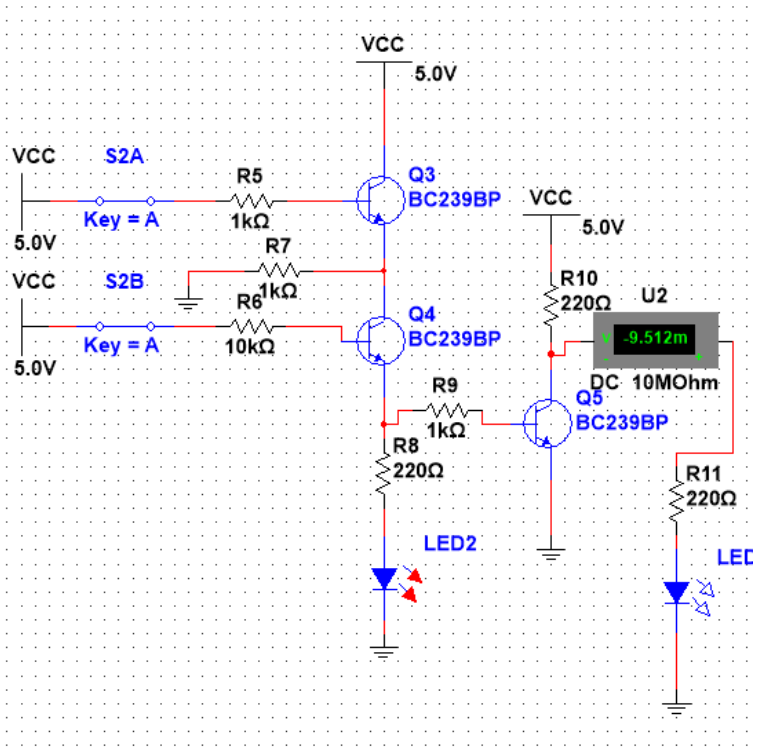


Table 2: AND

| | Input | Input | Output | Output |
|---|---|---|---|---|
| | A | B | LED | $V_out$ |
| 1 | 0v | 0v | 0v and 0v | -3.746m |
| 2 | 0v | 5v | 0v and 0v | -4.1v |
| 3 | 5v | 0v | 0v and 0v | -3.746v |
| 4 | 5v | 5v | 5v and 0v | -9.512mv |

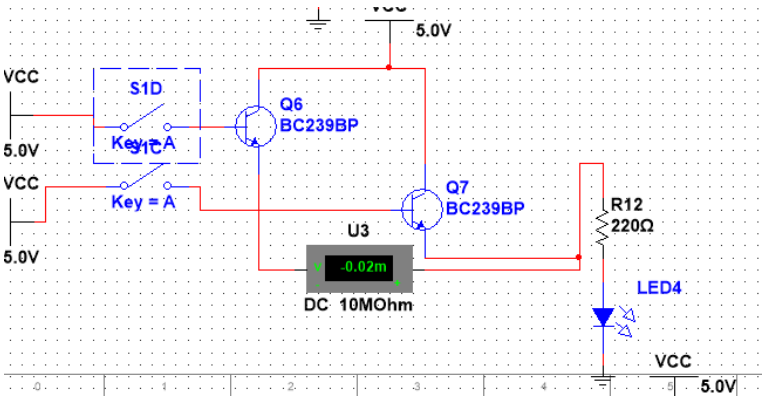
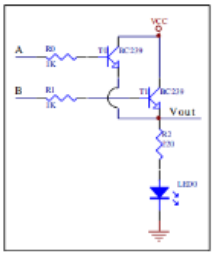



Table 3: OR

| | Input | Input | Output | Output |
|---|---|---|---|---|
| | A | B | LED | $V_out$ |
| 1 | 0v | 0v | 0v | -0.002m |
| 2 | 0v | 5v | 5v | 0.715v |
| 3 | 5v | 0v | 5v | -3.318v |
| 4 | 5v | 5v | 5v | -0.305v |

**TEST QUESTIONS**

1.For the circuit below if $V_A$=0 $V_B$=0 transistor $T_0$ is____, transistor $T_1$ is_____, $LED_0$ is____.
A. ON, ON, ON B. ON, ON, OFF C. OFF,ON, OFF
D. OFF, OFF, ON E. OFF, OFF, OFF




2.Fill in the gaps in the text: to turn on an NPN transistor, a _____ voltage is applied to the _____. When transistor is turned on, its collector-to-emitter becomes a _____.
A. negative, base, short B. positive, base, short C. negative, emitter, open
D. positive, emitter, short E. positive, emitter, open

3. How many states has the switch got?
A. 1 B. 2 C. 3 D. 4 E. 5

4. Bipolar transistor has:
A. 1 p-n-junction B. 2 p-n-junctions C. 3 p-n-junctions
D.1, or 2, or 3 p-n-junctions E. any number of p-n-junctions

5. The second strip to obtain resistance 120 Ω must be
A. white B. Green C. Brown D. Yellow E. red

6. What statement is wrong?
A. (X+Y)(X+Z)=X+YZ B. X(Y+Z)=XY+XZ C. X+XY=X
D. (XY)´=(X+Y)´ E. X(X+Y)=X

7. The truth table for XOR gate is:

A

| X | y | F |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

B

| x | y | F |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

C

| x | y | F |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

D

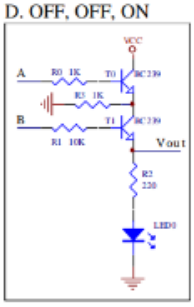
| X | y | F |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

E

| x | y | F |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

8. For the circuit below if $V_A$=0 $V_B$=5V transistor $T_0$ is____, transistor $T_1$ is_____, $LED_0$ is____.

A. ON, ON, ON  B. ON, ON, OFF  C. OFF,ON, OFF
D. OFF, OFF, ON  E. OFF, OFF, OFF




9. The truth table for NAND gate is:

A

| X | y | F |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

B

| x | y | F |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

C

| X | y | F |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

D

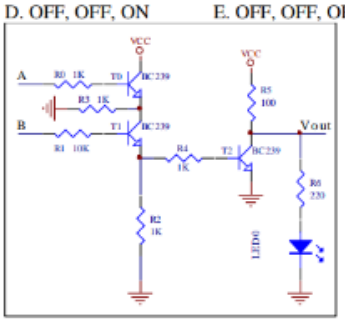
| X | y | F |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

E

| x | y | F |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

10. For the circuit below if $V_A$=5V $V_B$=0 transistor $T_0$ is____, transistor $T_1$ is_____, transistor$T_2$ is____.

A. ON, ON, ON  B. ON, OFF, OFF  C. OFF,ON, OFF
D. OFF, OFF, ON  E. OFF, OFF, OFF




1. **For the circuit below if VA=0 VB=0 transistor T is:**
   The answer is C. OFF, ON, OFF.

   **Here's why:** When VA and VB are both 0, there is no base current flowing through the NPN transistor T. With no base current, the transistor is in the OFF state. Since the transistor is off, there is no collector current flowing through it. With no collector current, the LED is also OFF.

2. **Fill in the gaps in the text: to turn on an NPN transistor, a positive voltage is applied to the base, and its collector-to-emitter becomes a short.**
   This statement is correct. NPN transistors require a positive voltage on the base to turn on. When the transistor is on, the collector-to-emitter path acts like a short circuit, allowing current to flow from the collector to the emitter.

3. **How many states has the switch got?**

The answer is B. 2. The switch has two positions: on and off. There is no middle ground or additional states.

4. **Bipolar transistor has:**
   The answer is C. 3 p-n-junctions. A bipolar transistor is made up of three layers of semiconductor material, p-type, n-type, and p-type again, forming two p-n junctions.

5. **The second strip to obtain resistance 120 must be:**
   Unfortunately, I cannot answer this question definitively without more information. The color coding of resistors depends on the specific tolerance and resistance value coding system being used. It would be helpful to have the complete color bands of both resistors or the specific coding system being used in the circuit.

6. **What statement is wrong?**
   The answer is D. (XY)=(X+Y).

   **Here's why:** The correct answer is C. X+XY=X. The distributive property states that A(B+C) = AB + AC. In the statement (XY)=(X+Y), we can see that A=X, B=X, and C=Y. Applying the distributive property, we get X(X+Y) = XX + XY. However, XX = X (since any number multiplied by itself equals itself), so the equation becomes X(X+Y) = X + XY. Therefore, statement D is incorrect.

7. **The truth table for XOR gate is:**
   The provided truth table is correct. An XOR gate outputs a HIGH (1) only when its inputs are different. When both inputs are the same, the output is LOW (0).