Laboratory Assignment 1: Logic Abstraction

ECE 0201: Digital Circuits and Systems

45 Points

Name

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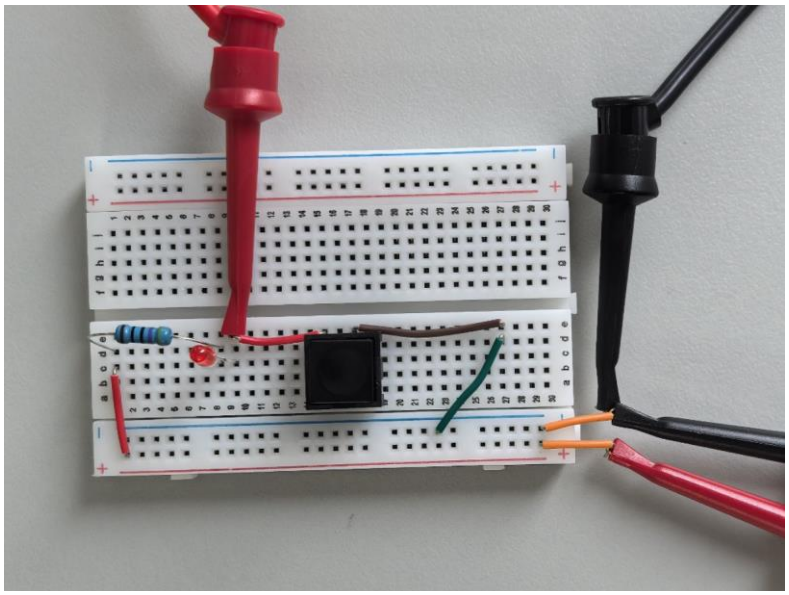
Submission Checklist:

- ☐ Write within boxes, do not move boxes
- ☐ Write your full name in the box above
- ☐ Save this file as a PDF before uploading, keep the number of pages (**13**) unchanged
- ☐ Note “TO BE CONTINUED” in the answer box if you used the extra pages (11-13)

Part I: Single Input LED/Switch Circuits (10 points)

LED and Switch in Series (2.5 points)

[(A) Insert a picture of your build of the circuit] (0.5 points)



[(B) Fill out the following information] (1 points)

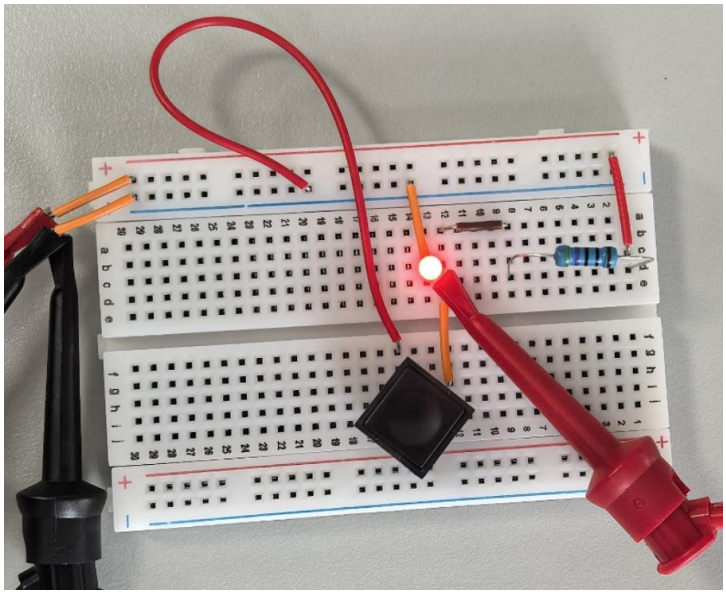
V_x when the switch is closed = 0.337mV
V_x when the switch is opened = 3.536V
LED state (on/off) when the switch is open = OFF
LED state (on/off) when the switch is closed = ON

[(C) Briefly compare your voltage measurements to what you expect] (1 points)

1. When the switch is off, the voltmeter is shorted and shows 0V. Since the wire and switch have resistance, once the switch is open, the circuit becomes open, and the voltmeter should read 5V. But as stated in the instructions, the LED has a typical forward voltage of 1.7V. Therefore, it is reasonable that the voltmeter displays 3.536V, indicating a 1.5V drop across the LED, which is very close to the typical value.

LED and Switch in Parallel (7.5 points)

[(A) Insert a picture of your build of the circuit shown in Figure 5] (0.5 points)



[(B) Fill out the following information] (1 points)

V_x when the switch is closed = 0.630mV
V_x when the switch is opened = 1.94845V
LED state (on/off) when the switch is open = ON
LED state (on/off) when the switch is closed = OFF

[(C) Briefly compare your voltage measurements to what you expect.] (1 points)

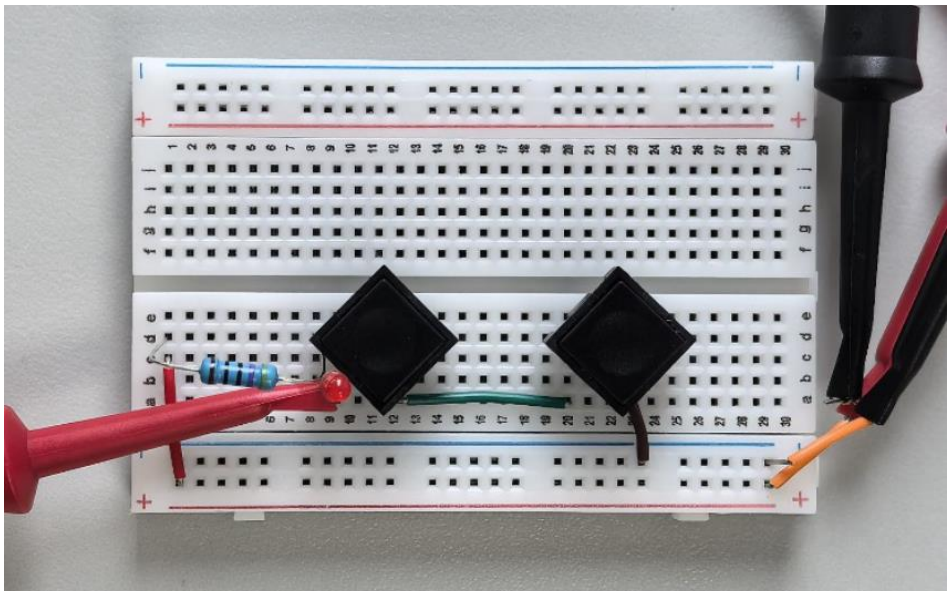
1. When the switch is open, the LED lights up and operates normally. Vx represents the potential difference across the LED. Since R1 takes part of the voltage, the measured Vx matches expectations.
2.
3. When the switch is closed, the LED is bypassed, and no current flows through it, so Vx should be 0V. Because the wire has resistance, a slight voltage appears, making Vx equal to 0.630 mV, which is reasonable.

[(D) Demonstrate your circuit to an instructor or TA for the first part of the lab checkoff] (5 points)

Part II: Multiple Input Switch / LED Circuits (20 points)

LED and Two Switches in Series (5 points)

[(A) Insert a picture of your build of the circuit] (0.5 points)



[(B) Fill out the following information] (1.5 points)

S1	S2	V_x	V_y	LED (on/off)
Open	Open	3.5326V	-0.005mV	OFF
Open	Closed	3.5357V	0.279mV	OFF
Closed	Open	3.5363V	3.5457V	OFF
Closed	Closed	0.540mV	0.660mV	ON

[(C) Select a logic abstraction, draw a truth table, and explain what type of logic gate this circuit represents] (1.5 points)

Logic abstraction: AND

Truth table (1-T,0-F)

S1	S2	Result
0	0	0
0	1	0
1	0	0
1	1	1

Assume:

switch close is 1, open is 0;

LED on is 1, off is 0.

The 2 switches are 2 inputs, the LED is an output.

The output is true only if both inputs are true, so we can say it

[(D) Draw a second truth table with a second logic abstraction (no need to retake measurements)] (1.5 points)

Logic abstraction: OR

Truth table

S1	S2	Result
1	1	1
1	0	1
0	1	1
0	0	0

Assume:

switch close is 0, open is 1;

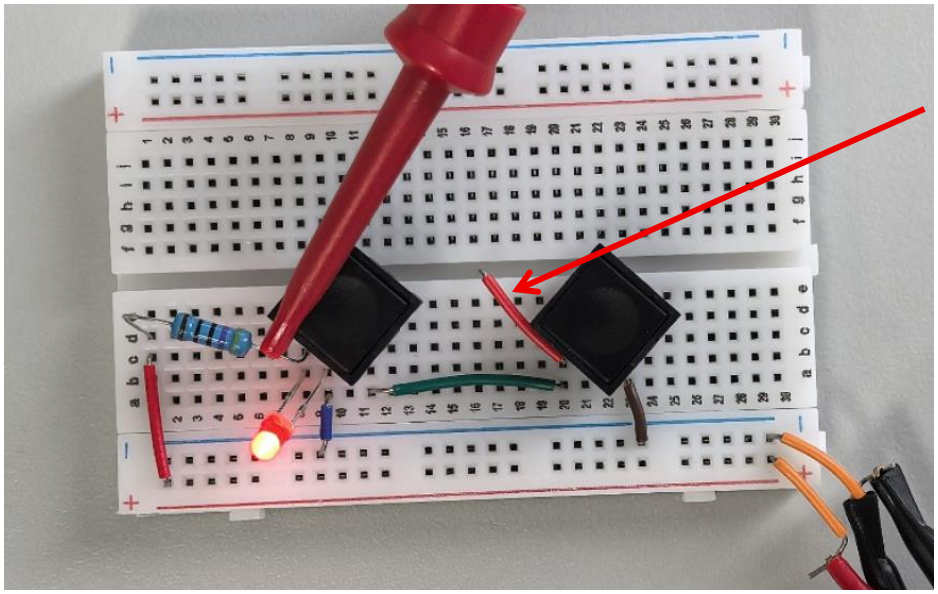
LED on is 0, off is 1.

The 2 switches are 2 inputs, the LED is an output.

If there is a 1 in the 2 inputs, the result is 1. So, it can be an OR.

LED in Parallel with Two Series Switches (5 points)

[(A) Insert a picture of your build of the circuit] (0.5 points)



This wire is prepared for voltage measurement.

[(B) Fill out the following information] (1.5 points)

S1	S2	V_x	V_y	LED (on/off)
Open	Open	1.94881V	0.435mV	ON
Open	Closed	1.94738V	0.052mV	ON
Closed	Open	1.94771V	1.94715V	ON
Closed	Closed	0.922mV	0.446mV	OFF

[(C) Select a logic abstraction, draw a truth table, and explain what type of logic gate this circuit represents] (1.5 points)

Logic abstraction: AND

Truth table

S1	S2	Result
0	0	0
0	1	0
1	0	0
1	1	1

Assume:

switch close is 1, open is 0;

LED on is 0, off is 1.

The 2 switches are 2 inputs, the LED is an output.

If and only if there are double 1, the result is 1, it is an AND.

[(D) Draw a second truth table with a second logic abstraction (no need to retake measurements)] (1.5 points)

Logic abstraction: OR

Truth table

S1	S2	Result
1	1	1
1	0	1
0	1	1
0	0	0

Assume:

switch close is 0, open is 1;

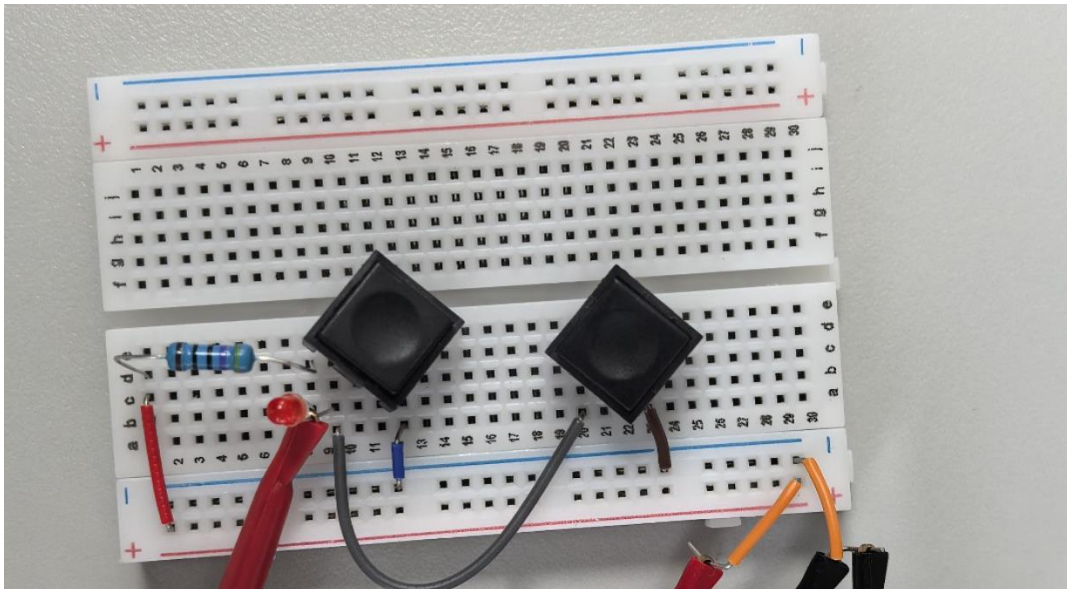
LED on is 1, off is 0.

The 2 switches are 2 inputs, the LED is an output.

If there is more than one value of 1, the result is 1. It's an OR.

LED in Series with Two Parallel Switches (5 points)

[(A) Insert a picture of your build of the circuit] (0.5 points)



[(B) Fill out the following information] (1.5 points)

S1	S2	V_x	V_y	LED (on/off)
Open	Open	3.5358V	3.5358V	OFF
Open	Closed	0.410mV	0.409mV	ON
Closed	Open	0.383mV	0.385mV	ON
Closed	Closed	0.250mV	0.248mV	ON

[(C) Select a logic abstraction, draw a truth table, and explain what type of logic gate this circuit represents] (1.5 points)

Logic abstraction: OR

Truth table

S1	S2	Result
0	0	0
0	1	1
1	0	1
1	1	1

Assume:

switch close is 1, open is 0;

LED off is 0, on is 1.

The 2 switches are 2 inputs, the LED is an output.

If there is more than one value of 1, the result is 1. It's an OR.

[(D) Draw a second truth table with a second logic abstraction (no need to retake measurements)] (1.5 points)

Logic abstraction: AND

Truth table

S1	S2	Result
1	1	1
1	0	0
0	1	0
0	0	0

Assume:

switch close is 0, open is 1;

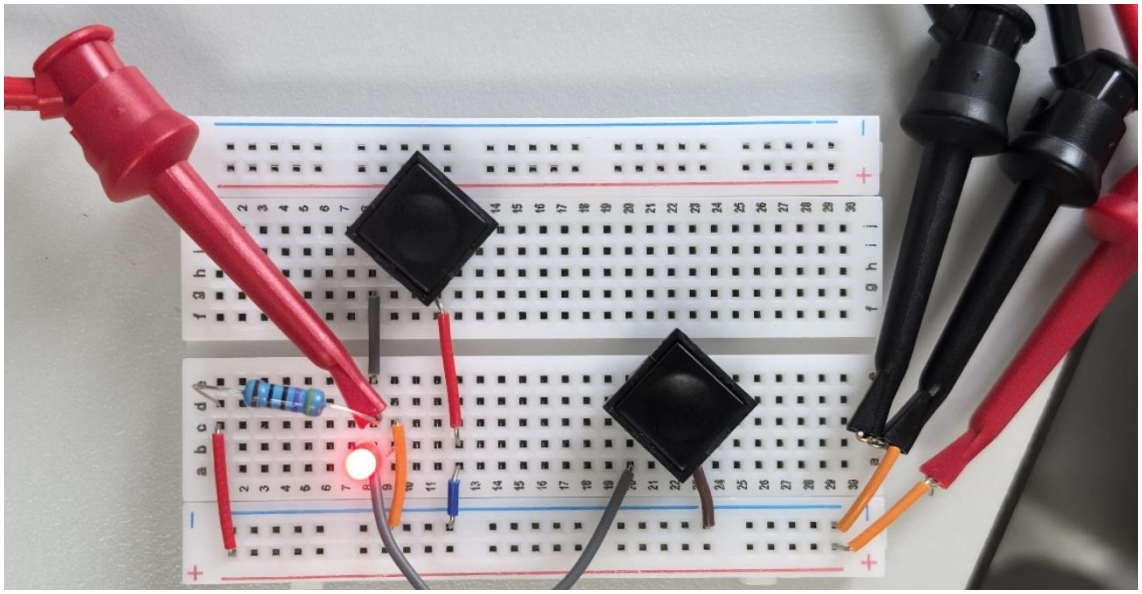
LED on is 0, off is 1.

The 2 switches are 2 inputs, the LED is an output.

If and only if all the switches are 1, the result is 1. It's the AND.

LED in Parallel with Two Parallel Switches (5 points)

[(A) Insert a picture of your build of the circuit] (0.5 points)



[(B) Fill out the following information] (1.5 points)

S1	S2	V_x	LED (on/off)
Open	Open	1.94939V	ON
Open	Closed	0.671mV	OFF
Closed	Open	0.734mV	OFF
Closed	Closed	0.440mV	OFF

[(C) Select a logic abstraction, draw a truth table, and explain what type of logic gate this circuit represents] (1.5 points)

Logic abstraction: AND

Truth table

S1	S2	Result
1	1	1
1	0	0
0	1	0
0	0	0

Assume:

switch close is 0, open is 1;

LED on is 1, off is 0.

The 2 switches are 2 inputs, the LED is an output.

If and only if all the switches are 1, the result is 1. It's the AND.

[(D) Draw a second truth table with a second logic abstraction (no need to retake measurements)] (1.5 points)

Logic abstraction: OR

Truth table

S1	S2	Result
0	0	0
0	1	1
1	0	1
1	1	1

Assume:

switch close is 1, open is 0;

LED on is 0, off is 1.

The 2 switches are 2 inputs, the LED is an output.

If there is more than one value of 1, the result is 1. It's an OR.

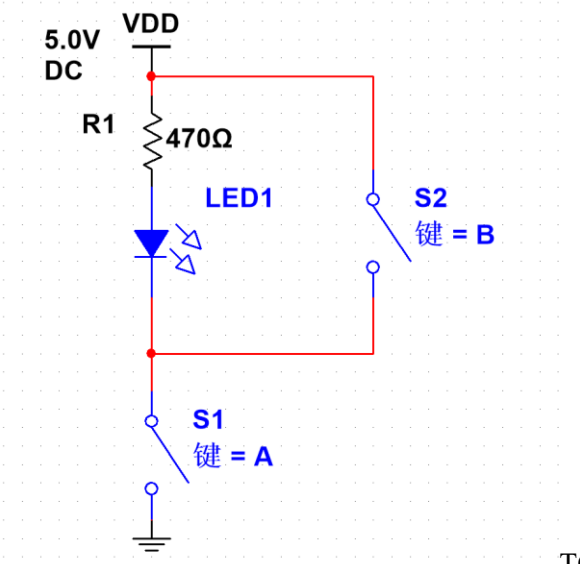
Part III: Logic Design (15 points)

[(A) Solve the truth table for the provided Boolean function, define a logic abstraction, and draw a circuit schematic] (1.5 points)

Step 1: Solve truth table and define logic abstraction:

A	B	f
1	1	1
1	0	0
0	1	1
0	0	1

Step 2: Develop and draw circuit schematic:



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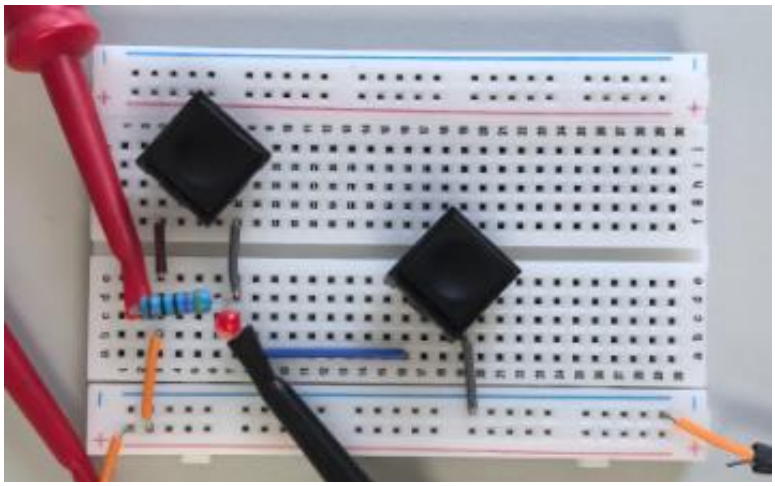
[(B) Insert an image of your build of the circuit you designed] (0.5 points)



[(C) Organize your measurements into a single table showing switch states, voltage measurements, and LED states. Also, translate the table into a truth table showing logical values] (1.5 points)

S1	S2	V_x	LED (on/off)
Open	Open	-28.197mV	OFF
Open	Closed	-0.005mV	OFF
Closed	Open	4.9976V	ON
Closed	Closed	0.150V	OFF

Truth table

S1	S2	Result
0	0	1
0	1	1
1	0	0
1	1	1

Assume:

switch close is 1, open is 0;

LED on is 0, off is 1.

The 2 switches are 2 inputs, the LED is an output.

[Demonstrate your circuit to the instructor or TA for the second part of the lab check-off.] (11.5

EXTRA PAGES

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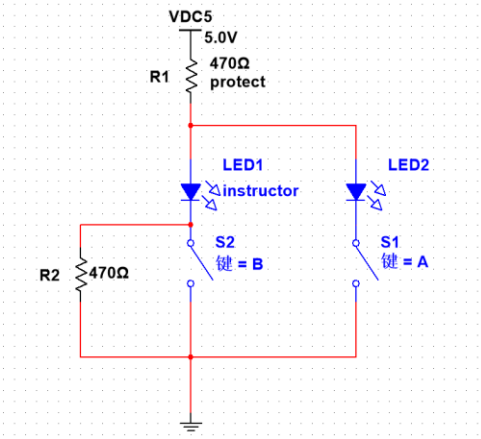
PART 3-A

Besides the circuit satisfy the stem (1 LED, 2 switches, Vdd=5V), we also designed another circuit, which satisfies instinct better.

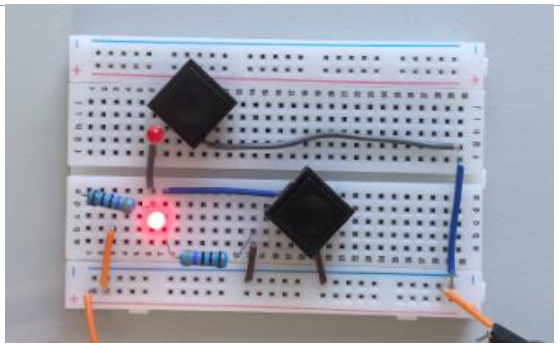
The circuit use 2 LEDs, 2 switches. The closed switch (breakover) is 1, and the lighted LED is 1.

Follows the circuit schematic.



Then the truth table

A	B	Ā	f
1	1	0	1
1	0	0	0
0	1	1	1
0	0	1	1



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