Laboratory Work – Part 1

Project A: Basic Electronics and Lab Skills

Project Name Lab Work – Part 1 | Project ***A*** | ***u3191010***

Objective To build a simple electronic circuit to power up an LED. Use resistors to ensure that too much voltage doesn't arrive at the LED and cause it to fail.

Hypothesis If done correctly, the LED will light up properly and will not fail due to the resistors in the circuit.

Materials

- ETS-5000 Logic Trainer
- Selection of resistors including one 470Ω
- Potentiometer (10k)
- Red LED
- Multimeter

Procedure

1. Collect three resistors from the given selection. Use the resistor colour code chart to decipher their values.
2. Then measure their actual values using the multimeter (set the range switch to the appropriate resistance scale).
3. Record your findings.
4. Excluding the power source, connect the circuit as shown in Figure 3. The LED has polarity and turns on only if connected the right way. The long lead usually connects to a positive source and is called the anode, the other is called the cathode.
5. Connect the power and using the potentiometer, identify the point at which the LED changes its state (i.e. turn on/off). Measure the voltage across the LED at this point and record the result.

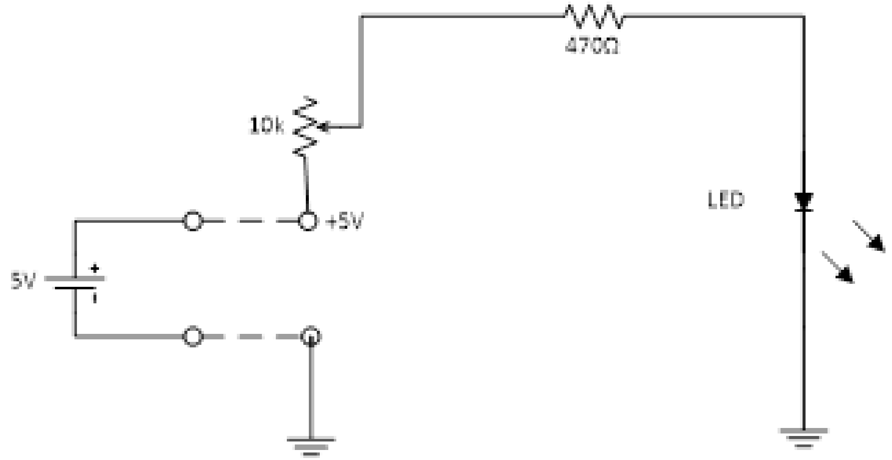


Figure 3

Tabulated Data

Resistor Measurements:

No. of colour bands in the resistor/colours	Nominal Value of the Resistor (Ω)	Measured Value of the Resistor (Ω)
4	$470 \pm 5\%$	468
5	$39 \pm 1\%$	39.7
5	$470 \pm 1\%$	470

Resistor Networks:

	Nominal Value (Ω)	Measured Value (Ω)
Resistors in Parallel	33.4	34
Resistors in Series	979	977

Voltage across the LED: 1.85 V

Analysis

For the resistors, the resistance values we derived through the colour coding were mostly similar to the resistance values that we measured using the multimeter. We got the same result for the resistor networks.

The LED was lit up successfully. The voltage across the LED was found to be 1.85 volts.

Conclusion

Our purpose for this lab exercise was to build a simple electronic circuit to power up an LED, and ensure it works properly using resistors. We first derived the resistance values for each resistor, as well as the resistance values for when they are in parallel and for when they are in series. Then we measured these values using a multimeter. We then used the multimeter, after building the circuit, to calculate the voltage across the LED. For the resistance values, the nominal values and the measured values were quite similar. We also managed to get the LED to light up and found the voltage across the LED at the point where it changes its state to be 1.85 volts. Overall, I learned to build a circuit on a trainer board and to read colour codes of resistors, as well as implement them into a circuit, and construct parallel and series resistor networks.

Project B: Basic Gate Functions

Experiment 1: Two-input AND Gate

Project Name

Lab Work – Part 1 | Project ***B1*** | ***u3191010***

Objective

To verify the operation and characteristics of a two-input AND gate.

Hypothesis

Based on mathematics, the output should only be HIGH, if both inputs are equal to 1.

Materials

- ETS-5000 Logic Trainer
- TTL IC 7408: Quad 2-input AND gates

Procedure

1. Connect the circuit as shown in figure 4. The IC used in this experiment contains four identical and independent AND gates and only one of them is used.
2. The input for the AND gate is obtained through logic switches Sw0 and Sw1. The output of the AND gate is connected to a Logic monitor (LED) which lights up red (1) when there is a high output condition and green (0) when there is a low output condition.
3. Connect pin 14 of the IC to V_{cc} (+5V) and pin 7 to ground (GND).
4. Now, with all possible combinations of Sw0 and Sw1, record the output voltages in a truth table.

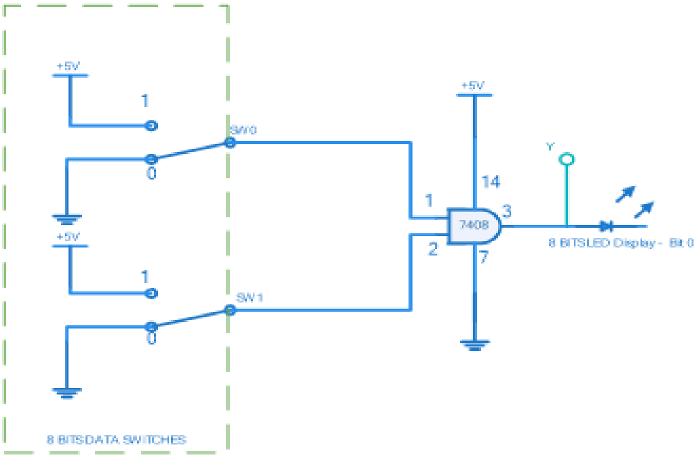


Figure 4

Tabulated Data

Output voltages for a Two-input AND Gate:

Switch Setting		Output
S_{w0}	S_{w1}	Y (V)
0	*0*	LOW
0	*1*	LOW
1	*0*	LOW
1	*1*	HIGH

Two Input AND Gate with Positive Logic Assignment:

Switch Setting		Output
A (=S_{w0})	B (=S_{w1})	Y
0	0	0
0	1	0
1	0	0
1	1	1

Analysis When both inputs are 1, the LED displays a red colour. For the other sets of inputs, the LED displays a green colour.

Conclusion In this experiment, we created and observed the operation and characteristics of a two-input AND gate. We created a two-input AND gate circuit using an IC chip, found the outputs for each possible set of inputs, and recorded it into a truth table. From the data, we can evaluate that the initial hypothesis is indeed correct. Both inputs must be 1 for an output of 1/HIGH/red. Otherwise, we get an output of 0/LOW/green. From this experiment, I learned how to set up a circuit with an AND gate on a trainer board, as well as what kind of results AND gates give us for different inputs.

Experiment 2: Three-input AND Gate

Project Name Lab Work – Part 1 | Project ***B2*** | ***u3191010***

Objective To build a 3-input AND gate using two 2-input AND gates and verify the operation and characteristics of a 3-input AND gate.

Hypothesis According to mathematics, all three inputs must be 1 for the output to be HIGH. Otherwise, the output will always be LOW.

Materials

- ETS-5000 Logic Trainer
- TTL IC 7408: Quad 2-input AND gates

Procedure

1. Connect the circuit as shown in **Error! Reference source not found.**. Only two AND gates from the IC are used.
2. The AND gate inputs can be connected through logic switches Sw0, Sw1, and Sw2.
3. The output of the AND gate is connected to a Logic monitor (LED) which lights up red (1) when there is a high output condition and green (0) when there is a low output condition.
4. Connect pin 14 of the IC to V_{cc} (+5V) and pin 7 to ground (GND).
5. Now, with all possible combinations of Sw0, Sw1, and Sw2, record the output voltages in a truth table.

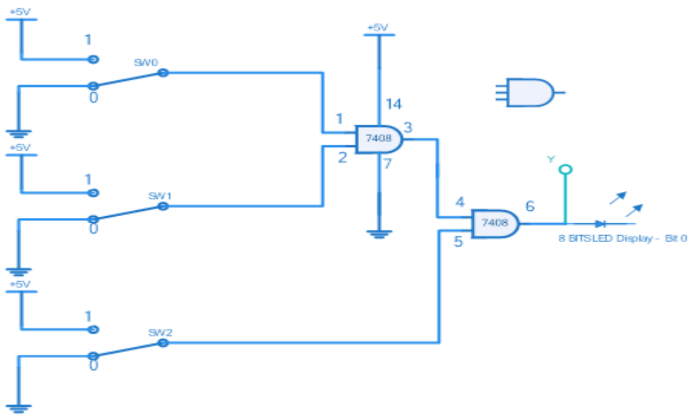


Figure 5

Tabulated Data

3-input AND Gate with Positive Assignment:

Inputs			Output
A (= S_{w0})	B (= S_{w1})	C (= S_{w2})	Y
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

Analysis

When all three inputs are 1, the LED displays a red colour. For the other sets of inputs, the LED displays a green colour.

Conclusion

In this experiment, we created and observed the operation and characteristics of a three-input AND gate. We created a three-input AND gate circuit using two two-input AND gates (two IC chips), found the outputs for each possible set of inputs, and recorded it into a truth table. From the data, we can evaluate that the hypothesis is correct. All three inputs must be 1 for an output of 1/HIGH/red. Otherwise, we get an output of 0/LOW/green. From this experiment, similar to experiment 1, I learned how to set up a circuit with an AND gate on a trainer board, and how we can create three-input AND gates from two-input AND gates, as well as what kind of results AND gates give us for different inputs.

Project C: An Industrial Alarm

Project Name

Lab Work – Part 1 | Project ***C*** | ***u3191010***

Objective

Derive simple combinational logic circuits from the problem description, simplify, and construct simple combinational logic circuits.

Problem Description

A manufacturing plant needs to have an alarm to indicate the time for the operators to leave. The alarm should sound when either of the following conditions is met:

- It's after 5 o'clock and all machines are shut down.
- It's Friday, the production run for the day is complete, and all machines are shutdown.

If you carefully look at the problem, there are four input conditions. Let's call them inputs **A**, **B**, **C**, and **D** such that:

A - It's 5:00pm or later;
B - All machines are shut down;
C - It's Friday;
D - Production run for the day is complete.

Let's assume that each input becomes HIGH (1) when the respective condition is met (e.g. input **A** will be HIGH only when the time of day is 5:00pm or later). Also assume that any variables/combinations that are not mentioned in the conditions above must be zero to sound the alarm.

Materials

- ETS-5000 Logic Trainer
- TTL IC 7408: Quad 2-input AND gates
- TTL IC 7432: Quad 2-Input OR Gate

Procedure

- The alarm will sound when the output (**X**) is HIGH. Create a truth table for the problem description above.
- Derive the resulting Boolean expression corresponding to the table.
- Simplify the above expression using Boolean algebra.
- Design the logic circuit corresponding to the original Boolean expression.
- Design the new logic circuit using only the gates available.
- Construct the modified circuit you designed in the previous step using the trainer board. Connect the four inputs (**A**, **B**, **C**, and **D**) to the first four switches (8 Bits data switches) on the digital trainer. Connect the output (**X**) to one of the LEDs (8 Bits LED Display). Connect V_{cc} (=+5V) and GND pins of the chips to digital trainer's power supply. Verify that your circuit operates according to the original requirements set out in the problem description by varying the input switches and recording the behaviour of the output LED (i.e. **X=1** LED is RED and **X=0** when LED is GREEN). Construct another truth table and compare to the previous table.

Tabulated Data

Expected Truth Table:

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

Boolean Expression: X = AB + BCD

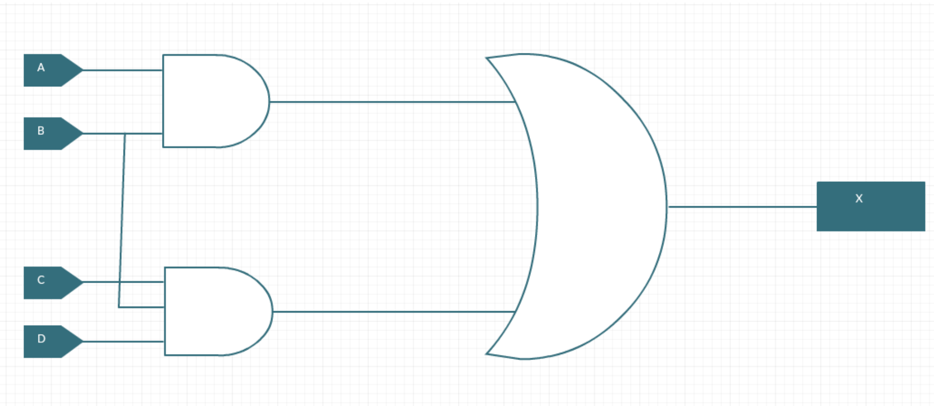
When you factorise using distributive law, you get: X = B (A + CD)

Resulting Truth Table (Same as the Expected Truth Table):

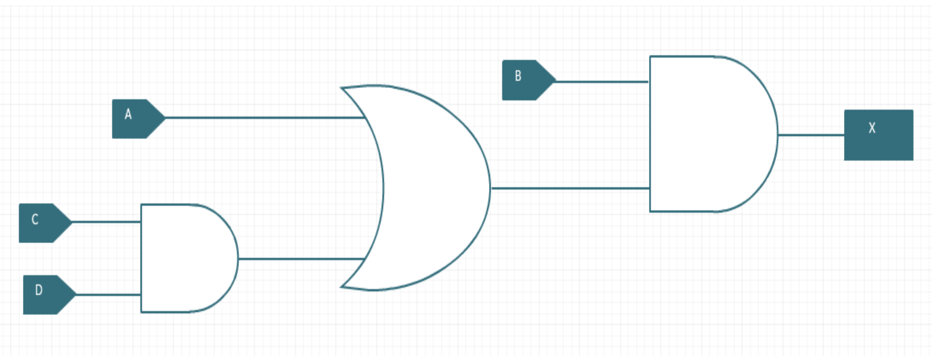
D	*C*	*B*	*A*	*X*
0	*0*	*0*	*0*	*0*
0	*0*	*0*	*1*	*0*
0	*0*	*1*	*0*	*0*
0	***0***	***1***	***1***	***1***
0	*1*	*0*	*0*	*0*
0	*1*	*0*	*1*	*0*
0	*1*	*1*	*0*	*0*
0	*1*	*1*	*1*	***1***
1	*0*	*0*	*0*	**0**
1	*0*	*0*	*1*	**0**
1	*0*	*1*	*0*	**0**
1	*0*	*1*	*1*	**1**
1	*1*	*0*	*0*	**0**
1	*1*	*0*	*1*	**0**
1	*1*	*1*	*0*	**1**
1	*1*	*1*	*1*	**1**

Analysis

Logic Diagram of X = AB + BCD:

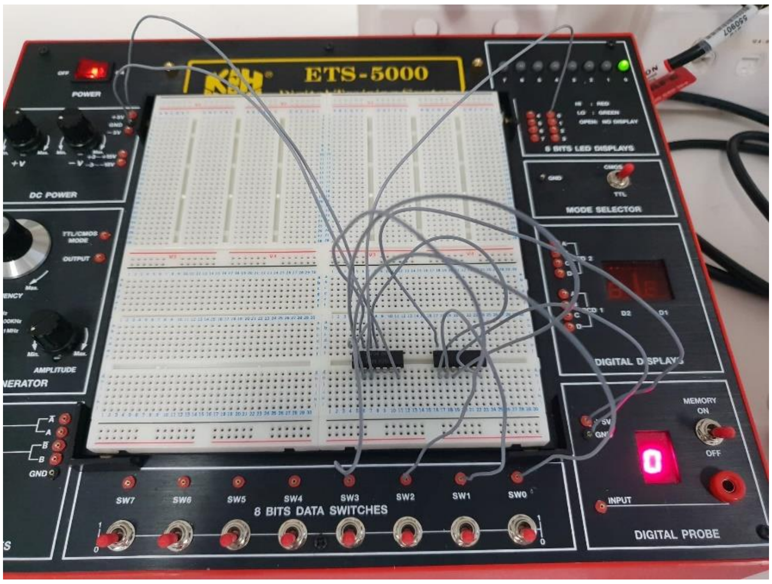


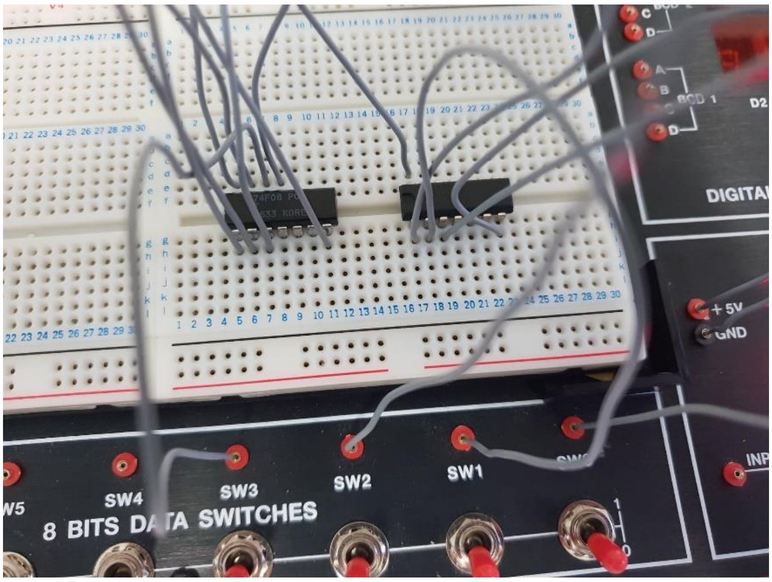
Logic Diagram of X = B (A + CD):



The expected truth table and the resulting truth table are the same.

Our Circuit:





Conclusion

The objective was to derive simple combinational logic circuits from the problem description, simplify, and construct simple combinational logic circuits. We constructed an expected truth table and derived a Boolean expression. We reformatted the equation so that we could construct a circuit with the two chips we were given. Then we constructed a truth table using the outputs the circuit gave us, and we compared the two truth tables we obtained. The two tables were equivalent. Hence, we were sure we did everything right. From this experiment, I learned to construct more complex circuits using AND/OR gates, as well as using theorems to restructure a Boolean expression in order to be able to construct a circuit with the limitations we are given.