Integrated Circuits Lab #1

AND Gates

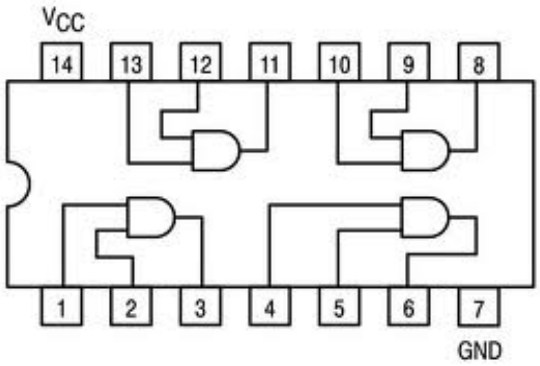
Materials Required:

Breadboard
Breadboard Power Supply
7408 AND Chip
8x 220 Ohm Resistors
8x LEDs
Jumper Wires

Part 1

Theory:

An AND gate is one of the six fundamental digital circuits. It accepts two electrical inputs and outputs a single electrical output, this controlling the flow of electricity through the circuit. The 7408 chip contains four separate AND gates. Pins 1 and 2 are inputs and pin 3 is an output for the first gate. Below is a diagram showing the arrangement of Logic gates on the 7408 Chip.



The Boolean equation for an AND operation looks something like this:

$$Y = A \cdot B$$

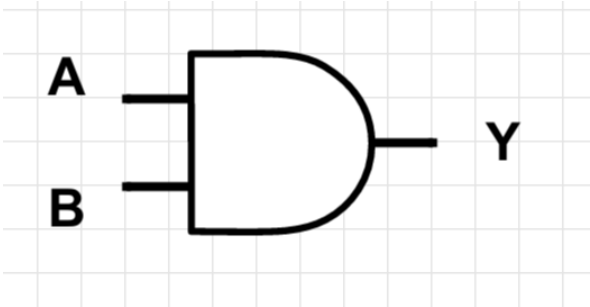
It is read as “Y equals A and B”. In this case Y represents the output of the gate, while A and B are both inputs. The dot represents the AND operation. We can also use Y = A & B to represent the AND operation. The input variables take on values of 1 or 0, in this case, as we choose. The output variable will take on a value of 1 or 0, depending on the inputs. The terms “1”, “logic high”, “HIGH”, and “logic 1” are all equivalent. The same holds true for “0”, “logic low”, “LOW”, and “logic 0”.

Purpose:

To investigate one gate of a 7408 AND chip.

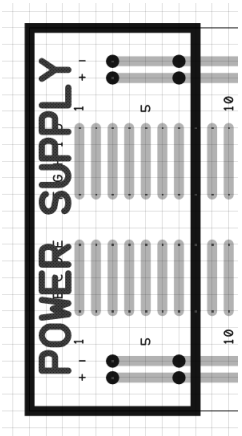
Procedure:

We will begin by wiring this simple logic circuit.

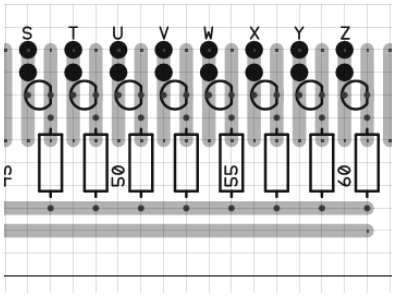


Complete wiring instructions or diagrams are given here, but later, you will be expected to wire logic circuits based on the gate diagram alone.

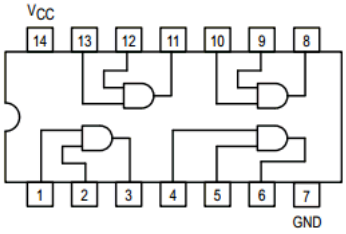
1. The first step in any of these labs will be to ensure your power and ground rails are actually connected to the power and ground terminals of a power supply. Our power supplies make this step fairly straight forward. "Plug in" the power supply to the breadboard as demonstrated in class, making sure the "+" and "-" signs are aligned correctly. Plug the power supply through the breadboard overlay paper provided for you. This overlay diagram will help you set up the rest of the circuit. It is easy to plug this in backwards if you aren't paying attention, and if this happens, you will cause problems for yourself later, so get it right the first time. Once your power supply is connected to the breadboard, connect it to a computer USB port with the provided cable. You can test to see that you are getting power by pressing the button on the power supply and looking for the green light, but you should always leave the power supply off when you are building your circuits.



2. Next, we need to set up the output indicators, so we can see the results of the logic operations we are testing. The overlay diagram has symbols that represent LEDs and resistors. The LEDs must be inserted in the correct orientation. If you can identify the flat side of the LED, that will correspond to the flat side on the symbol. The LEDs are small and it can be hard to see some of their features, so if you are unsure if you are doing right, ask a nearby peer for help.



3. Now place the 7408 AND chip on the breadboard straddling the groove. When inserting chips into a breadboard, make note of where the dimple or notch is. Some ICs have dimples, others have notches, and some have both. The dimple/notch should be oriented on the left side. This will ensure that your pins are easily identifiable. With the IC oriented like this, the pins are numbered starting with #1 on the lower left side, and increasing in a counter-clockwise pattern around the outline of the chip. Each pin on the chip must be firmly inserted into a hole on a distinct vertical row. To connect to a given pin on the chip, connect a wire to any hole in the same vertical row as the pin.

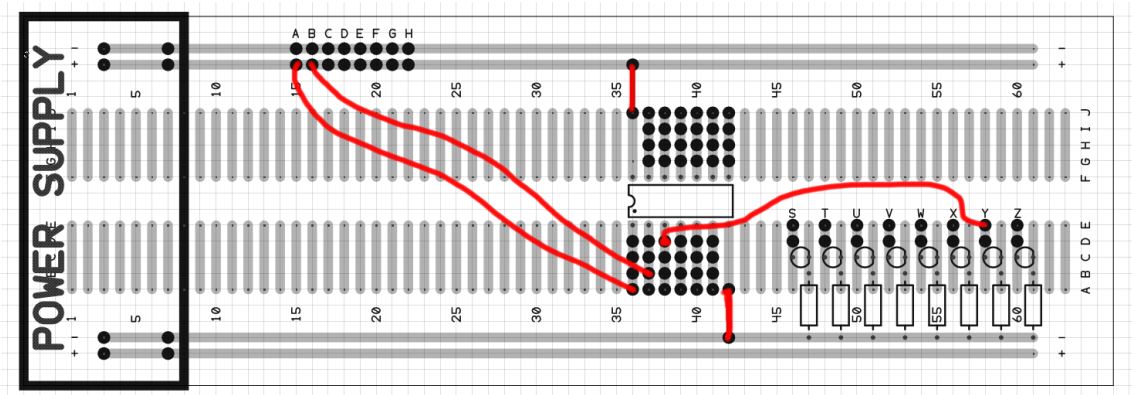


Note: When wiring elements together, you must make certain that the insulation on the ends of the wires have been stripped off so that the metal core of the wire is inserted into the hole. Strip only what is necessary (0.5cm – 1.0cm). Excess exposed wire can create electrical connections where we don't want them.

4. You are set up to wire the gate, now here are the detailed steps to connect the IC:
   - Connect pin 7 to the ground rail
   - Connect pin 14 to the power rail
   - Connect pin 1 to input A. You can control whether input A is HIGH or LOW, 1 or 0, by plugging your jumper into the positive or negative rails of the breadboard.
   - Connect pin 2 to input B
   - Connect pin 3 to output Y

5. Once the circuit is setup, we can set the inputs to the AND gate by plugging the appropriate jumper wire either to the power rail for a 1 (HIGH), or the ground rail for a 0 (LOW). The LED for the Y output will light up depending on the result of the logic operation. A shining LED indicates a result of 1, and an unlit LED indicates a 0.

6. Refer to the following diagram to check your wiring.



Questions:

1. Draw a gate diagram of this circuit, using A and B as inputs, and Y as output.
2. Complete the following truth table by setting the inputs as specified for each row of the table and observing and recording the outputs.(0 = off, 1 = on)

A	B	Y
0	0	
0	1	
1	0	
1	1	

3. Describe in words the combination of states (1s or 0s) that A and B must hold, in order for the output at Y to be HIGH.
4. Describe in words the combination of states (1s or 0s) that A and B must hold, in order for the output at Y to be LOW.
5. For the Boolean expression $Y = A \cdot B$, what will the result Y be under the following circumstances?
    a. A = 0, B = 1
    b. A = 0, B = 0
    c. A = 1, B = 1
6. How many gates are there in a regular 7408 chip?
7. How many pins are there in a regular 7408 chip?
8. How many output states does a single AND gate have?
9. What is the Boolean equation for Y in terms of A and B?

Part 2

Purpose:

To investigate two gates of a 7408 chip (two levels)

Theory:

The second AND gate in a 7408 chip has pins 4 and 5 as inputs and pin 6 as output. Two gates of one 7408 are now being used.

The circuit we will build can be represented by two separate Boolean equations:

$X = A \cdot B$

$Y = X \cdot C$

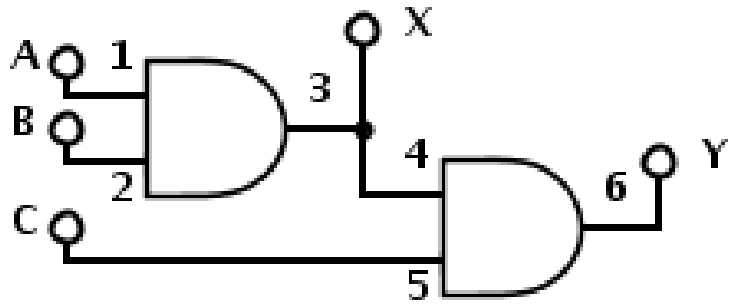
However, more simply, we can combine these and represent this whole circuit with one equation:

$Y = (A \cdot B) \cdot C$

Note how brackets are used to signify order of operations. The $(A \cdot B)$ operation is conducted first, and that result is fed into the second AND operation. Take a look at the diagram that follows for clarification.

Procedure:

We will use the following diagram to wire the circuit.



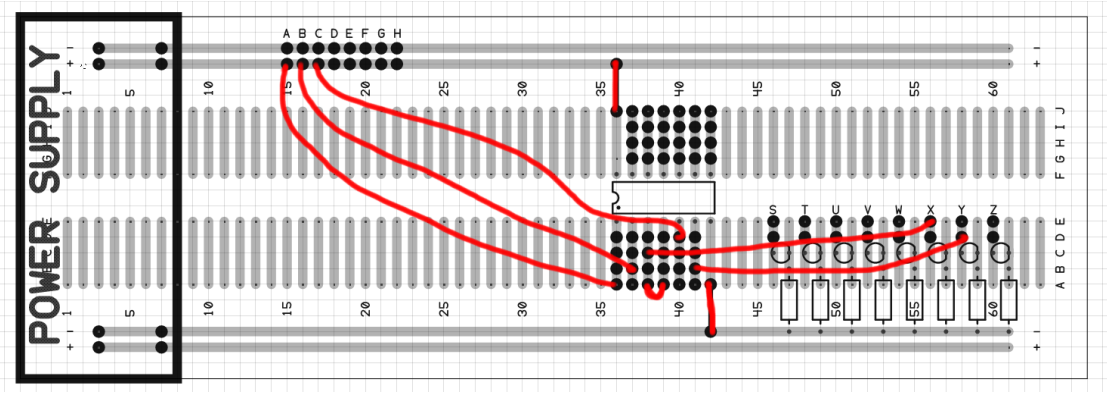
Follow these steps to wire the circuit:

1. Ensure your breadboard is powered by inserting your power supply and testing that it functions.
2. Ensure that your 7408 chip is inserted correctly into the breadboard, straddling the bridge in the middle, **with the notch/dimple facing left**

For the Integrated Circuit:

3. Connect pin 7 to the ground rail
4. Connect pin 14 to the power rail
5. Connect pin 1 to input A
6. Connect pin 2 to input B
7. Connect pin 3 to pin 4
8. Connect pin 5 to input C
9. Connect pin 3 to output X
10. Connect pin 6 to output Y

Refer to the following diagram to check your wiring.



Questions:

1. Draw a gate diagram of your circuit, using A, B and C as input labels, and X and Y as output labels.
2. Using the assembled circuit on your breadboard, complete the following truth table by setting the inputs as specified for each row of the table and observing and recording the outputs.(0 = off, 1 = on)

A	**B**	**C**	$X = A \cdot B$	$Y = (A \cdot B) \cdot C$
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

3. Describe in words the combination of states (1s or 0s) that A and B must hold, in order for the output at X to be HIGH.
4. Describe in words the combination of states (1s or 0s) that A, B, and C must hold, in order for the output at Y to be HIGH.

5. For the Boolean equation $Y = (A \cdot B) \cdot C$, what will the result Y be under the following circumstances?
    a. A = 1, B = 1, C = 1
    b. A = 0, B = 0, C = 0
    c. A = 1, B = 0, C = 1

6. There exist AND gates that take **three** inputs, and produce a single output. How do you think the gate diagram symbol for a gate like this would look? Draw one.

7. Write the Boolean equation for the output Y in terms of the inputs A, B, and C.

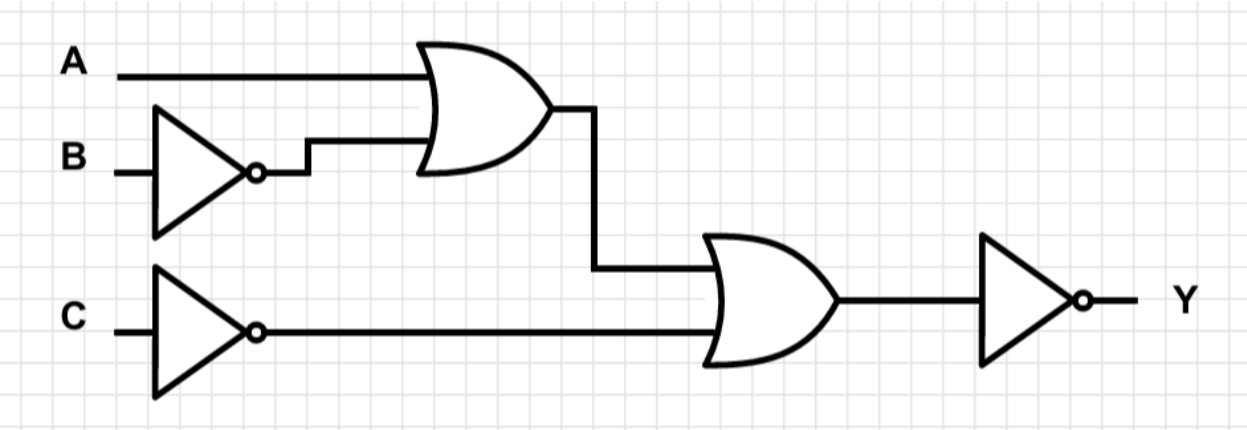
Part 3

Purpose:

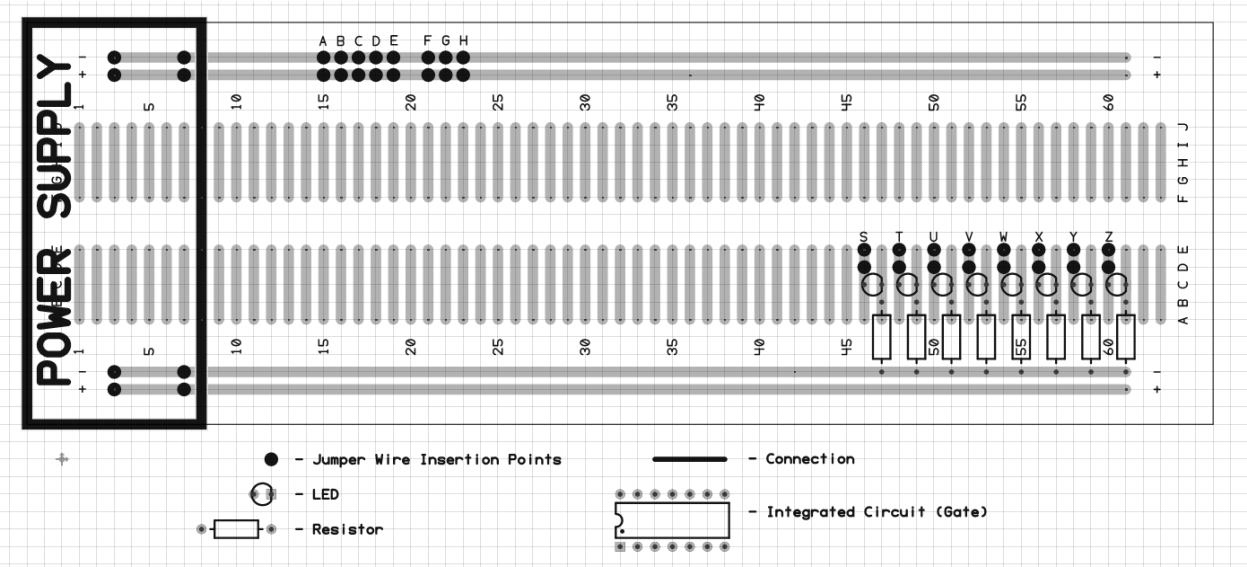
To build and examine a complex gate circuit using more than one type of gate.

Procedure:

We will build the following circuit on our breadboards:



1. Carefully consider and plan the layout of your circuit by drawing it on the diagram below. You will still require only one OR IC and only one NOT IC, but you will be using more of the available pins for each. Again check with a partner, then another group, then with the teacher to be sure you are confident your plan is correct.



2. Wire your real-life breadboard circuit by following your plan.

3. Like before, once the circuit is setup, we can set the inputs as we wish by plugging the appropriate jumper wire either to the power rail for a 1 (HIGH), or the ground rail for a 0 (LOW). You will need to do this for some of the questions below.

Questions:

1. What would the Boolean equation for this circuit look like?

2. Using the assembled circuit on your breadboard, complete the following truth table by setting the inputs as specified for each row of the table and observing and recording the outputs.(0 = off, 1 = on)

3. How many gates are being used in this circuit?
    a. NOT?
    b. OR?
    c. TOTAL?

4. How many pins of each IC are free (not connected to anything)?
    a. NOT IC?
    b. OR IC?