ICE 1 - OR Gates

Due: Lesson 6

Lab Objectives:

1. Implement and test a simple logic design in hardware.
2. Gain experience using hardware.

Agenda:

1. Build the required circuit.
2. Test your circuit.
3. Demonstrate the circuit's operation to an instructor.

Supplies:

1. 5x 1 $k\Omega$ resistors.
2. 1x red LED.
3. 1x SN7432 2-Input OR gate logic chip.
4. 1x breadboard power supply.
5. 1x breadboard.
6. 1x 4-dip switch.
7. Jumper wires.

Collaboration:

For this lab, work in teams of two. You may seek help from any ECE 281 instructor or authorized online resource, but may not utilize any student. Documentation is required (you do not need to document work with your partner). We expect all code to be your own work.

1 Purpose.

In this course you have learned how to design basic combinational logic circuits. In this ICE you will implement a basic logic design using transistor-transistor logic (TTL) chips. This will help you prepare for Lab 1. You will implement the simple logic equation:

$$Y = A + B + C + D$$

If any input, A, B, C, or D, is high (logic one), then the output, Y, is high (logic one). If all four inputs are low (logic zero), then the output is low (logic zero). You will use a `SN7432` TTL chip to build this logic equation, which includes four, 2-Input OR Gates. You can find the data sheet for the chip on the Team under *Data Sheets*. Figure 1 provides the chip layout.

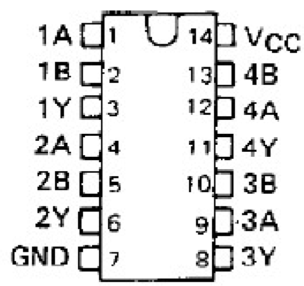

Figure 1: SN7432 TTL Layout

The SN7432 chip only contains 2-Input OR gates, but the logic equation requires a 4-Input OR gate. Boolean algebra can be used to find an arrangement of 2-Input OR gates that will work. The simple logic equation can now be represented as:

$$Y = (A + B) + (C + D)$$

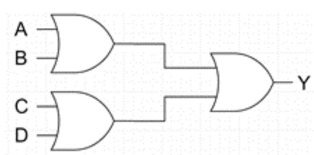

Figure 2

The 4-Input OR equation is now implemented using three, 2-Input OR gates.

2 Build the required circuit.

2.1 Breadboards

A breadboard is a prototyping device that allows you to easily connect different portions of a circuit together. Figure 3 depicts how the breadboard used in this ICE is connected. Each row (on either side of the center line) is a single node. This means two devices can be connected together by inserting them in the same row. Additionally, each of the columns on the outside of are connected the entire length of the board. These columns are ideal for supplying power and ground to your circuits.

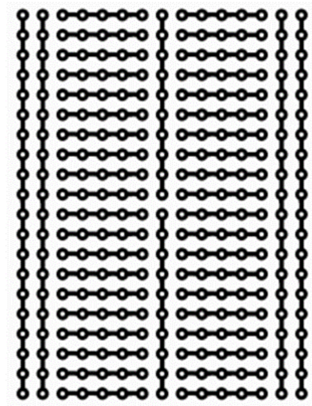

Figure 3: Breadboard connections

2.2 Power Supply

You will use a USB power supply to power your circuit. Attach the power supply to the top of the breadboard so the red vertical lines align with the 5V and 3.3V pins and the blue lines align with the ground pin according to Figure 4. Insert the USB cable into your computer. Press the white button to turn on the power supply.

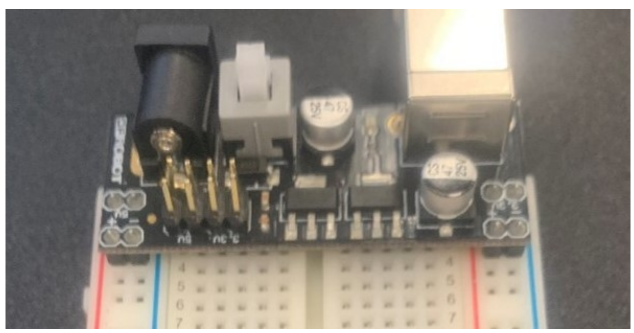

Figure 4: Power supply placement

You will use a digital multi-meter (DMM) to test the power supply. Turn the multimeter to the 20 V DC voltage setting and place the black lead into the ground rail and the red lead into the 5 V rail according to Figure 5.

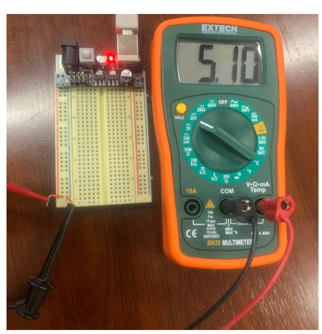

Figure 5: Testing power supply

The meter should read about 5 V. Once you have successfully tested, turn off your power supply by depressing the white button.

2.3 Switches and Resistors

Next you are going to configure your input switches. This portion of the circuit will allow us to provide a logic '0' to the circuit (0 V or low) when the switch is not active and a logic '1' to the circuit (5 V or high) when the switches is active. The switches and resistors are going to be in a pull down configuration or active high. This means when the switch is "open" there is a direct connection between the circuit and ground through a resistor which pulls the value to 0. This provides a logic '0'. However, when the switch is "closed", the circuit is now connected to the power supply (5 V). This provides a logic '1'. We will use $4x$ 1 $k\Omega$ resistors and 4-switch component.

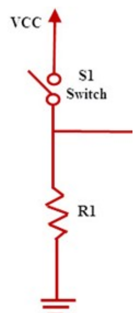

Figure 6: Pull-down resistor configuration

Figure 7 shows how to connect the 4-dip switch and 4 resistors on the breadboard.

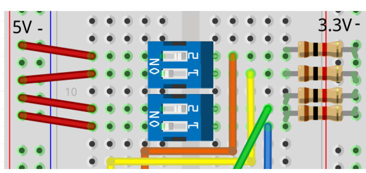

Figure 7: 4-Dip switch and resistor configuration

Now you will test the circuit. Connect the black lead of your DMM to ground and connect the red lead to one of the switch **OUTPUTS** (right side of switch). Select th 20V DC voltage option on your meter and turn on your USB power supply. The meter should read about 5 V. When active, the switch acts just like a wire, therefore, we should see the same value from the voltage source. The meter should read 0 V when the switch is not active. Repeat this testing for each of the four switches. When complete, turn off the power supply.

2.4 7432 Chip

You will now add the 7432 chip, which provides 4 logic OR gates. You will place the chip along the center spacing to ensure each lead of the chip is on its own node (and not connected). Note the indentation on the switch, this is the **TOP**. You will wire the `Vcc` pin to 5 V and the `GND` pin to ground (the negative '-' on the power supply). Each of the switch outputs will be wired to one of the gate inputs and the outputs of the two gates will be connected to the inputs of a third gate. The switch outputs are located between the resistor and the switch. Connect the switch 1 output (top-most switch) to pin 1 on the chip. Connect the switch 2 output to pin 2 on the chip. Connect the switch 3 output to pin 4 of the chip. Connect the switch 4 output (bottom-most switch) to pin 5 of the chip. Next you need to connect the outputs of the first two OR gates to the third OR gate. Pin 3 needs to be connected to pin 10 and pin 6 needs to be connected to pin 9. Figure 8 demonstrates how the switch outputs should be connected. The blue bar is ground (the negative on the USB) and the red bar is Vcc (5V).

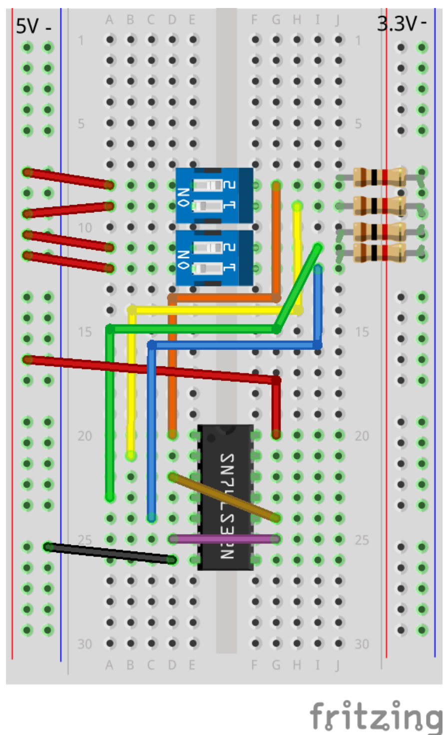

Figure 8: SN7432 Wiring

You can test to ensure everything is working by connecting the black lead of the DMM to ground and the red lead to the output of pin of the final OR gate (Pin 8). Turn on the power and test your circuit. According to our equation, if any of the switches are active, the output of the chip should be high (logic '1' or 5V). Notice that the meter is reading closer to 4.5 V and not 5 V. Luckily, according to the data sheet seen in Figure 9, anything above 2 V is considered high or logic '1'. This means that 4.5 V would register as a logic '1' and anything less than 0.8 V would register as a logic '0'.

		SN5432			SN7432			UNIT
		MIN	NOM	MAX	MIN	NOM	MAX	
V_{CC}	Supply voltage	4.5	5	5.5	4.75	5	5.25	V
V_{IH}	High-level input voltage	2			2			V
V_{IL}	Low-level input voltage			0.8			0.8	V

Figure 9: SN7432 High and low voltage ratings

2.5 LED

The final step is to wire the LED. This LED will indicate if the circuit output is a logic '1' (LED is on) or logic '0' (LED is off). To prevent the LED from blowing up due to a potential current spike, you will wire the LED in series with a 1 $k\Omega$ resistor. LEDs are directional components. The longer of the LED's two leads should be on the positive side of the circuit (the side receiving the voltage or Pin 8 on the chip). The other indicator of the LEDs polarity is flat edge on the LED which should be placed towards ground. Wire up the LED according to Figure 10.

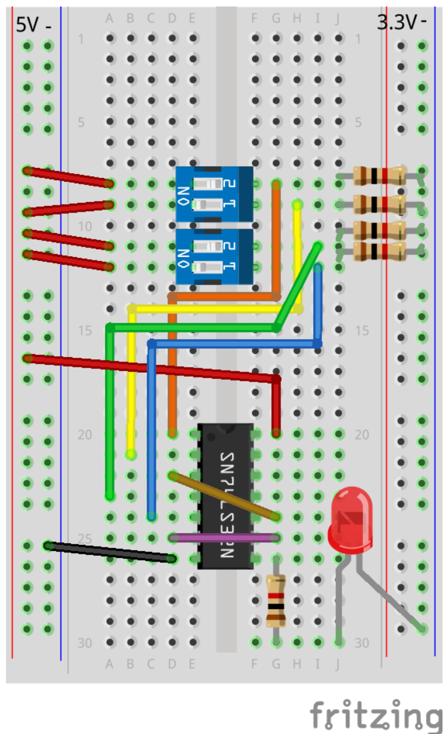

Figure 10: Test LED configuration

For your final test, simply turn on the power and test your switches. If any of the switches are turned "on" the LED will light up. If all of the switches are "off", the LED should remain off.

CONGRATULATIONS! You have successfully completed Exercise 1. This will be directly applicable to your circuit building in lab 1! Demonstrate your operational circuit to your instructor.