Lab 3:
Breadboard Implementation of a Combinational Logic Circuit

ELEC1710

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1 Introduction

In this lab you will be given a Boolean expression and are required to implement that expression on a breadboard using a combination of AND, OR and NOT gates. This lab will prepare you for Part B of your project.

2 Equipment

To perform this lab you will require:

- A breadboard and associated power supply
- 2x Tactile push button switches
- 2x 1k Ω resistors
- 2x 10k Ω resistors. (1K will also work if 10K not available)
- 1x Quad 2-input AND gate chip
- 1x Quad 2-input OR gate chip
- 2x LEDs

3 Reference Data

There are many different chips available which implement the AND, OR and NOT operations. These are typically based off either the 74- series (TTL) or 4000 series (CMOS) chips.

From the 74- Series you could use the following:

- 7408 Quad 2-input AND
- 7432 Quad 2-input OR

The same functions are implemented in the following 4000 series CMOS devices:

- 4071 Quad 2-input OR
- 4081 Quad 2-input AND

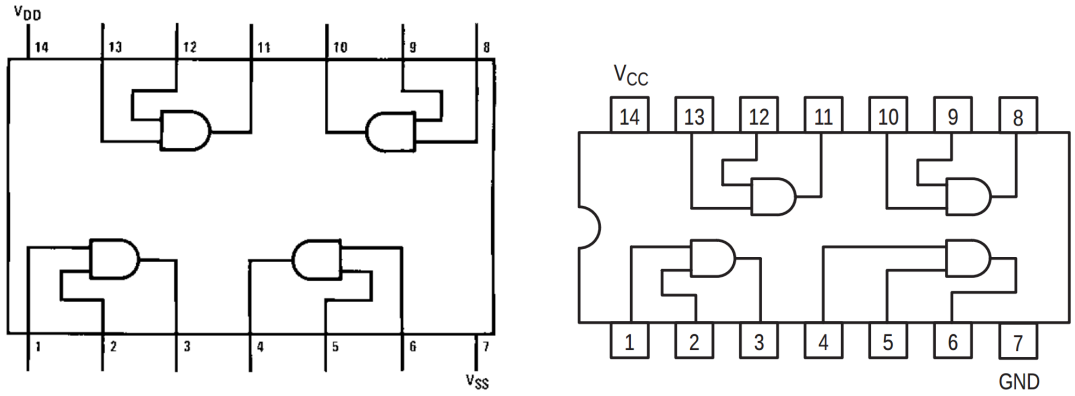
Note that the numbers printed on chips will typically include a *logic family* code. For example:

- 74HCxx - High speed CMOS
- 74LSxx - Low power schottky

Devices from different logic families differ in speed, power consumption, etc while maintaining the same pin configuration.

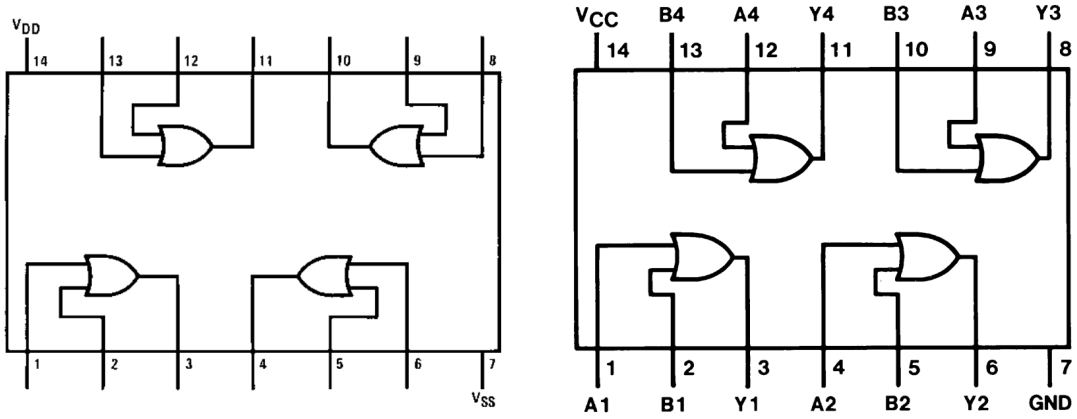
3.1 Pinouts

Refer to Figures 3, 1 & 2 for pinouts of the NOT, AND & OR gates, respectively. Note that the pinouts differ between some 74xx and 4xxx series devices.



(a) 4081 Pinout (b) 7408 Pinout

Figure 1: Quad 2-input AND gate pinouts. Note that V_{DD} is another name for V_{CC}.



(a) 4071 Pinout (b) 7432 Pinout

Figure 2: Quad 2-input OR gate pinouts. Note that V_{DD} is another name for V_{CC}.

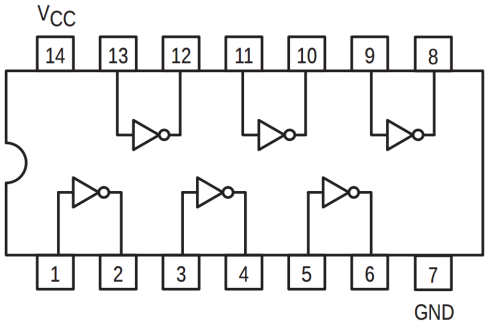


Figure 3: Pinout for 7404 and 4069 hex inverter chips.

4 Prework

Your lab task is to implement the following Boolean expressions:

$$S = A\overline{B} + \overline{A}B \tag{4.1}$$

$$C = AB \tag{4.2}$$

These expressions implement a binary half-adder where S and C correspond to the *sum* and *carry* outputs (respectively) and will be connected to LEDs. The variables A and B are the two binary bits to be added and will be generated by the push buttons with pull down resistors as in previous labs.

Tasks:

1. Complete the truth table for Equations 4.1 and 4.2:

A	B	S	C

2. Draw a logic circuit implementation of Equations 4.1 and 4.2 on the next page. Include the switches, their pull down resistors and output LEDs with their resistors. Use 10kΩ resistors for the switches and 1kΩ resistors for the LEDs.

3. Annotate the circuit with chip pin numbers around each gate. Use either the 7400 series or 4000 series pinout depending on what is available in the lab.

Draw the circuit diagram on this page

5 Construction Procedure

1. Insert the power supply unit onto the breadboard and confirm that the output voltages are set to +3.3 V as done in previous labs.
2. Insert two tactile switches and wire them up in an *active high* configuration as done in previous labs.
3. Insert the three logic chips into the breadboard leaving a 1 cm gap between them so they can be easily removed.
4. Connect all three V_{cc} pins to +3.3 V.
5. Connect all three GND pins to breadboard ground.
6. Insert the two LEDs close to where they will be connected to their logic chips. Bend their legs so that the negative (cathode, short leg) is inserted directly into breadboard ground and the other leg is in the main breadboard work area. Make sure they don't connect directly to any chip pins.
7. Use 1kΩ resistors to connect the LED's positive terminal to the correct logic chip pin.
8. Following your schematic make all other connections as required. Be systematic, cross off connections as you make them.
9. Power on the circuit and confirm that its output matches your truth table. If it does not work correctly you can use the Saleae analyser to help debug your circuit by connecting probes to the inputs, outputs, and any intermediate signals.