

Experiment 4: Multiplexing and Demultiplexing

Digital Systems and Microcontrollers | Monsoon 24

Objective: To design, assemble and test a (1:4) Multiplexer and (4:1) De-multiplexer using basic logic gates (whose select lines and inputs are through Arduino).

In the previous experiment, you learned the working of the basic logic gates. In this experiment we are going to use those logic gates to design multiplexer (or mux) and demultiplexer (or demux) Multiplexer and Demultiplexer:

A multiplexer (or mux) is a device that selects one of several analog or digital input signals and forwards the selected input into a single line. A multiplexer with 2^n inputs has n select lines, which are used to select which input line to send to the output.

Conversely, a demultiplexer (or demux) is a device taking a single input signal and selecting one of many data-output-lines, which is connected to the single input. A multiplexer is often used with a complementary demultiplexer on the receiving end.

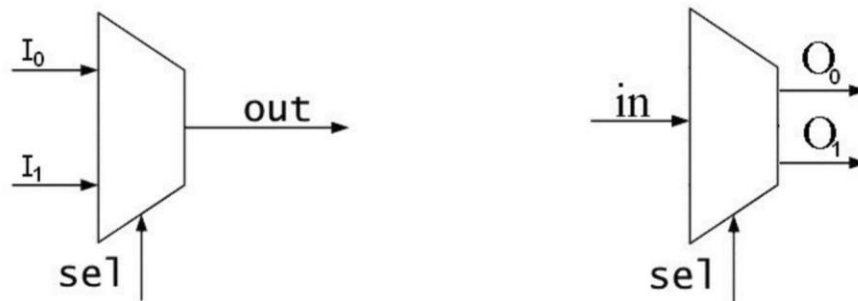


Fig.1 Multiplexer and Demultiplexer

Experiment:

□ Part-A: Design 4:1 Multiplexer using basic logic gates

A 4-to-1 multiplexer consists of four data input lines as I_0 to I_3 , two select lines as S_0 and S_1 and a single output line Y . The select lines S_0 and S_1 select one of the four input lines (D_0 through D_3) to connect to the output line. The figure below shows the block diagram of a 4-to-1 multiplexer.

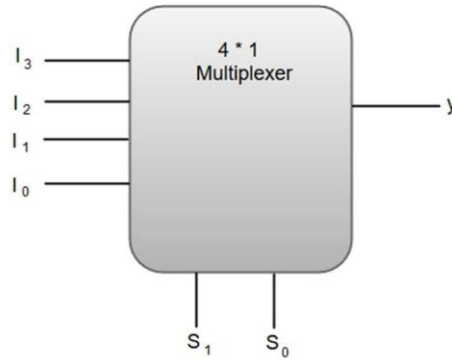


Fig.3 4:1 Multiplexer

The truth table of a 4-to-1 multiplexer is shown below in which four input combinations 00, 10, 01 and 11 on the select lines respectively switch the inputs I_0 , I_1 , I_2 and I_3 to the output. That means when $S_1=0$ and $S_0=0$, the output at Y is I_0 , similarly Y is I_1 if the select inputs $S_1=0$ and $S_0=1$ and so on.

S1	S0	y
0	0	I_0
0	1	I_1
1	0	I_2
1	1	I_3

From the above truth table, we can write the output expressions as

If $S_1=0$ and $S_0=0$ then $Y = I_0$

Therefore, $Y = I_0 (S_1)' (S_0)'$

If $S_1=0$ and $S_0=1$, the $Y = I_1$

Therefore, $Y = I_1 (S_1)' S_0$

If $S_1=1$ and $S_0=0$, then $Y = I_2$

Therefore, $Y = I_2 S_1 (S_0)'$

If $S_1=1$ and $S_0=1$ the $Y = I_3$

Therefore, $Y = I_3 S_1 S_0$

To get the total data output from the multiplexer, all these product terms are to be summed and then the final Boolean expression of this multiplexer is given as

$$Y = I_0 (S_1)' (S_0)' + I_1 (S_1)' S_0 + I_2 S_1 (S_0)' + I_3 S_1 S_0$$

The below figure shows the logic circuit of 4:1 MUX.

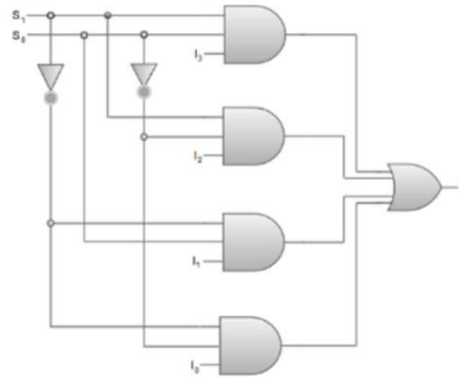
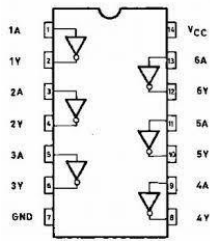
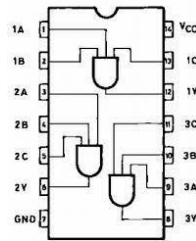


Fig.4 4:1 Multiplexer using logic gates

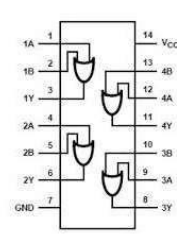
We will be using an inverter IC (74HC04), 2 AND gate ICs (74HC11) and 2 OR gate ICs (74HC32). The pin connections of these ICs are as follows.



74HC04 (INVERTER)



74HC11 (AND)



74HC32 (OR)

Fig.5 Logic gates pin diagrams

- 1) For the IC 74HC04 (Inverter) the data inputs are denoted by 1A, 2A, 3A, 4A and the data outputs by 1Y, 2Y, 3Y, 4Y.
- 2) For the IC 74HC11 (AND) and 74HC32 (OR), the data inputs are denoted by 1A, 1B, 1C and so on and the data outputs by 1Y, 2Y, 3Y.
- 3) Write an Arduino code to give different combinations of inputs at input and select lines and view them using LED at the output line.
- 4) Verify the multiplexer function by tabulating the values of the output(s) for all input combinations.

The below figure shows the final circuit of 4:1 MUX in Tinkercad:

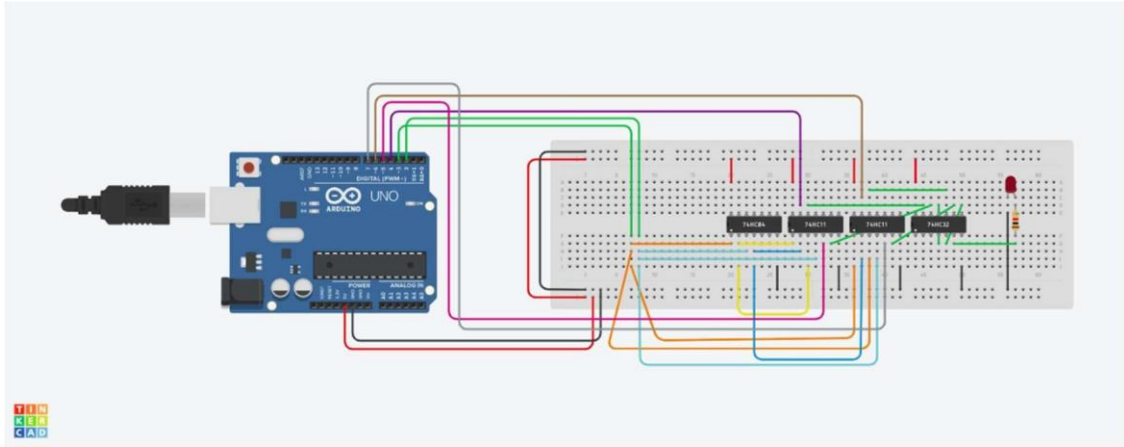


Fig.6 4:1 Multiplexer circuit

□ Part-B: Design 1:4 Demultiplexer using basic logic gates

A 1-to-4 demultiplexer consists of one data input line as i , two select lines as S_0 and S_1 and four output lines as y_0 , y_1 , y_2 and y_3 . The select lines S_0 and S_1 select one of the four output lines (y_0 through y_3) to connect to the input line. The figure below shows the block diagram of a 1-to-4 demultiplexer.

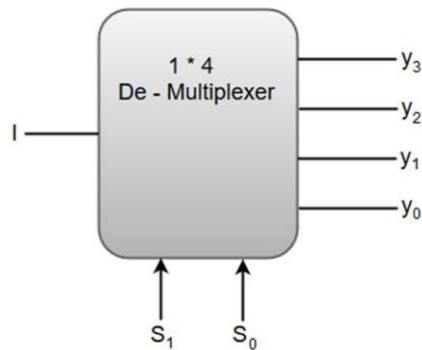


Fig.7 1:4 Demultiplexer

The truth table of a 1-to-4 demultiplexer is shown below in which four input combinations 00, 10, 01 and 11 on the select lines respectively switch the input to the output lines y_0 , y_1 , y_2 and y_3 . That means when $S_1=0$ and $S_0=0$, the output at Y is $y_0 = i$, similarly y_1 is i if the select inputs $S_1=0$ and $S_0=1$ and so on.

S_1	S_0	y_3	y_2	y_1	y_0
0	0	0	0	0	i
0	1	0	0	i	0
1	0	0	i	0	0
1	1	i	0	0	0

From the above truth table, we can write the output expressions as

If $S_1=0$ and $S_0=0$ then $y_0 = i$

Therefore, $y_0 = i (S_1)' (S_0)'$

If $S_1=0$ and $S_0=1$, the $y_1 = i$

Therefore, $y_1 = i (S_1)' S_0$

If $S_1=1$ and $S_0=0$, then $y_2 = i$

Therefore, $y_2 = i S_1 (S_0)'$

If $S_1=1$ and $S_0=1$ the $y_3 = i$

Therefore, $y_3 = i S_1 S_0$

From the above expressions of the outputs, a 1-to-4 demultiplexer can be implemented by using basic logic gates. The below figure shows the logic circuit of 1:4 DEMUX which is implemented by four 3-inputs AND gates and two 1-input NOT gate.

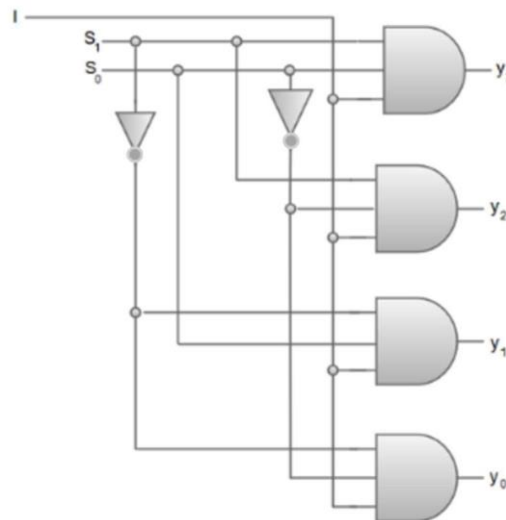


Fig.8 Demultiplexer using logic gates

Like the 4:1 MUX, we will be using an inverter IC (74HC04) and 2 AND gate ICs (74HC11). For the pin connections of these ICs, please refer to figure 5.

- 1) Write an Arduino code to give different combinations of inputs and select lines and view them using LEDs at the output lines.
- 2) Verify the demultiplexer function by tabulating the values of the output(s) for all input combinations.

The below figure shows the final circuit of 1:4 DEMUX in Tinkercad:

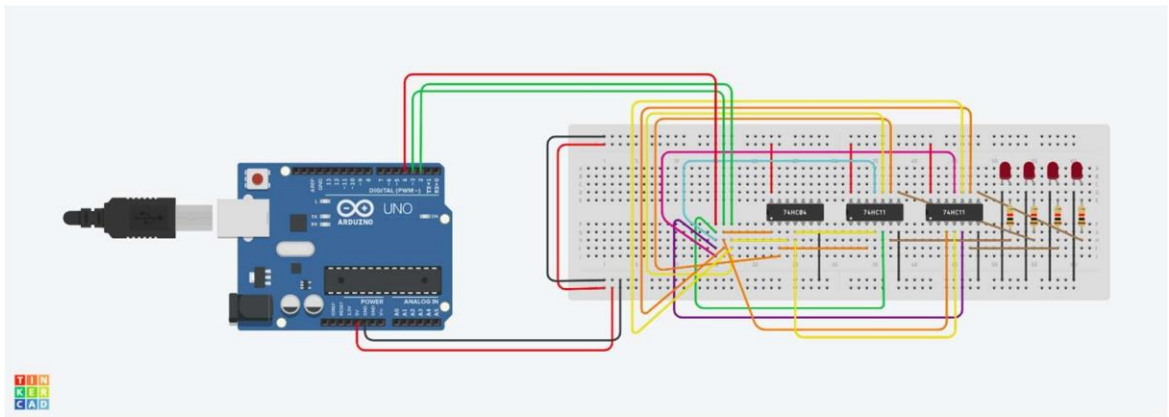


Fig.9 1:4 Demultiplexer

□ Part-C: Assemble and test circuits designed in Parts A and B

Write a program to give different combinations of inputs at MUX and view them at DEMUX output using LEDs.

Connect VCC and GND of both mux and demux to 5V and GND pin of Arduino. Connect 4 pins of Arduino to the mux as input pins. The output of the mux should be given as an input to the demux, and the select lines of both the mux and the demux must also be taken from Arduino. Connect the output of the demux to 4 LEDs. The block diagram and Tinkercad circuit diagram of the final circuit are given below.

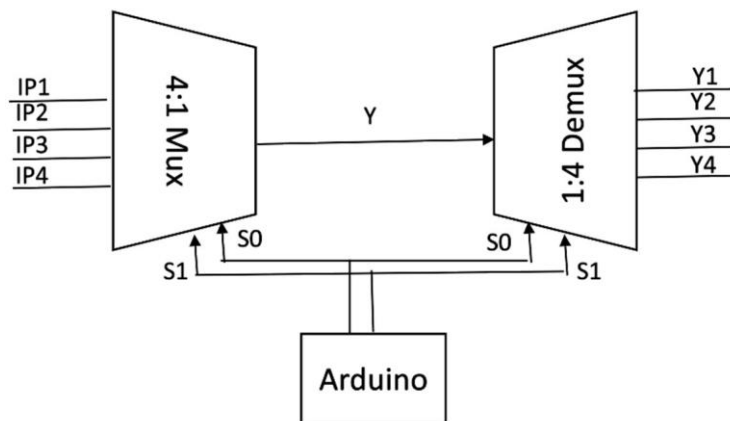


Fig.10 Block diagram

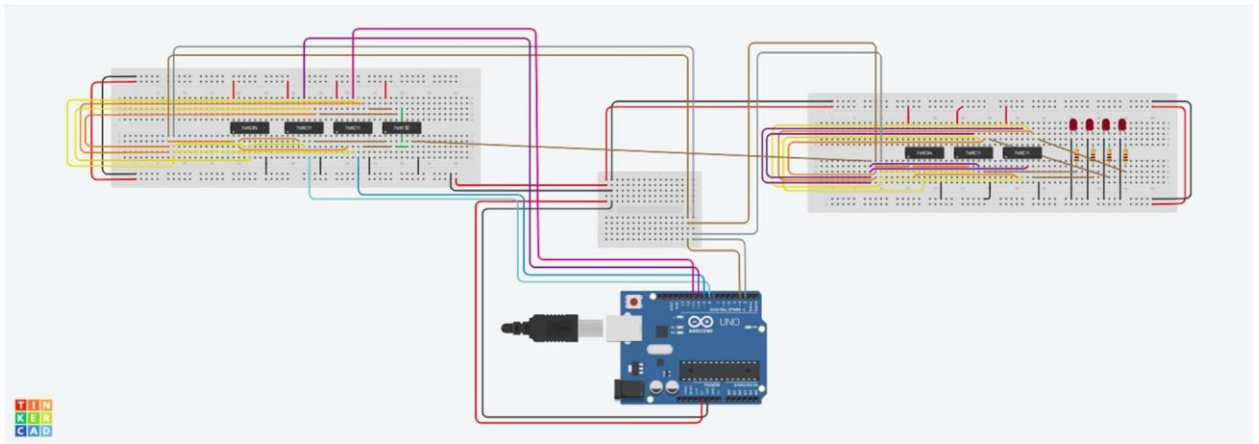


Fig.11 Final Circuit diagram