

Implementation of Boolean Logic in Arduino using ICs

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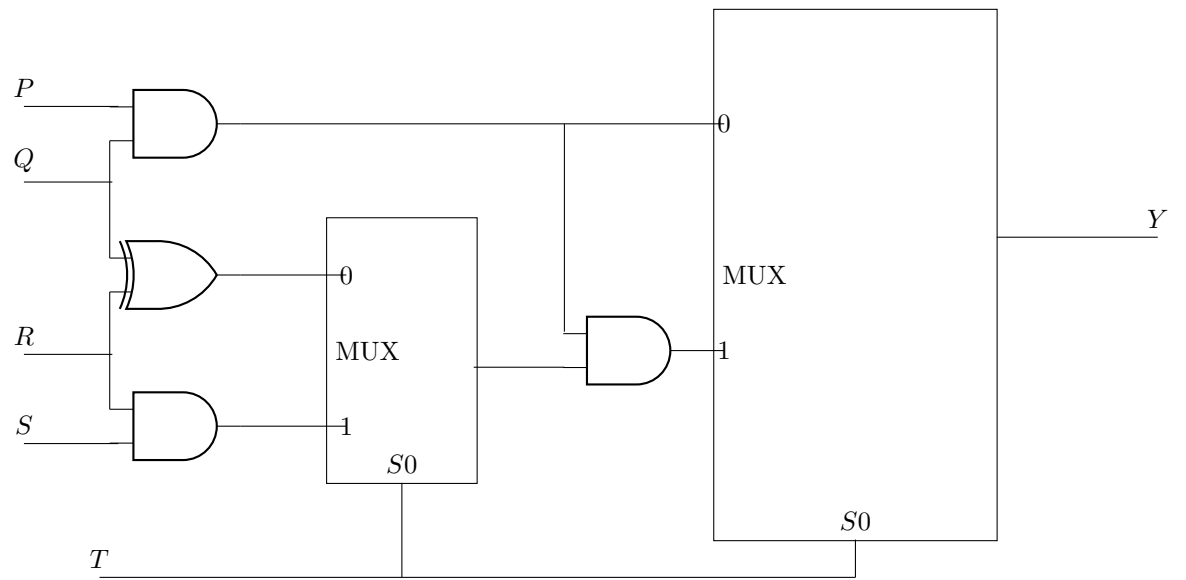
Contents

| | |
|-----------------------|----------|
| 1 Problem | 1 |
| 2 Introduction | 3 |
| 3 Components | 3 |
| 4 Hardware | 5 |
| 5 Software | 7 |

1 Problem

(Gate EC-2021)

Q.31. The propagation delays of the XOR gate, AND gate and multiplexer (MUX) in the circuit shown in the figure are 4 ns, 2 ns and 1 ns, respectively.



If all the inputs P, Q, R, S and T are applied simultaneously and held constant, the maximum propagation delay of the circuit is

1. 3 ns
2. 5 ns
3. 6 ns
4. 7 ns

2 Introduction

In the given circuit, the output of first multiplexer can be considered as the input to the second multiplexer so that the second multiplexer can be analyzed using 7447 IC for the implementation of output (expression) of the second multiplexer. Since the 7447 IC is just a seven segment display decoder, the output expression of the multiplexer can be given to the LSB representing pin (7) of the IC so that the output on the display will represent the required answer (0 or 1) with the inputs of the given circuit (P,Q,R,S,T) being given at random.

3 Components

Table 1: Table1
COMPONENTS

| Component | Value | Quantity |
|-----------------------|---------|----------|
| Resistor | 220 Ohm | 1 |
| Arduino | UNO | 1 |
| Seven Segment Display | | 1 |
| Decoder | 7447 | 1 |
| Jumper Wires | M-M | 20 |
| Breadboard | | 1 |

4 Hardware

1. Make Connections between the seven segment display in and the 7447 IC as shown in Table2.

Table 2: Table2

| 7447 - Display | | | | | | | |
|----------------|-----------|-----|-----------|-----|-----------|-----|-----------|
| 7447 | \bar{a} | b | \bar{c} | d | \bar{e} | f | \bar{g} |
| Display | a | b | c | d | e | f | g |

2. Connect Vcc of the IC and COM of the display to 5V and the GND pins of the IC and display to the Ground of arduino.

5 Software

1. Now make the connections as per Table3.

Table 3: Table3

| 7447 - Arduino | | | | |
|----------------|---|---|---|---|
| 7447 | D | C | B | A |
| Arduino | 5 | 4 | 3 | 2 |

2. In the truth table in Table4, P,Q,R,S,T are the inputs and Y is the output.

Table 4: Table4

| Truth Table | | | | | |
|-------------|---|---|---|---|---|
| P | Q | R | S | T | Y |
| x | x | 0 | x | x | 0 |
| x | x | x | 0 | x | 0 |
| 0 | 0 | x | x | 1 | 0 |
| x | x | 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 1 | x | 1 |

3. The k map for this truth table will be a five variable k map. So, two k maps can be drawn with one map having one input variable as zero and the other k map having that input variable as one as shown below.

| | | ST | | | | | | ST | | | |
|------|----|-------|----|----|----|--|--|-------|----|----|----|
| | | 00 | 01 | 11 | 10 | | | 00 | 01 | 11 | 10 |
| QR | 00 | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 |
| | 01 | 0 | 0 | 0 | 1 | | | 0 | 0 | 0 | 1 |
| | 11 | 0 | 0 | 0 | 1 | | | 0 | 0 | 1 | 1 |
| | 10 | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 |
| | | $P=0$ | | | | | | $P=1$ | | | |

4. Since, 7447 is a Seven Segment Display decoder, A represents the LSB and D represents the MSB. So giving the input to A displays either 0 or 1 on the Display.
5. Since, the output of the mux is either 0 or 1, this output of mux i.e, Y can be given as input to A of the 7447 IC so that the output of the mux can be observed directly on the display.
6. The boolean expression for the output (Y) of the second mux with the inputs (P,Q,R,S,T) will be simplified as 1

$$Y = RS(T' + PQ) \quad (1)$$

7. The code below realizes the Boolean logic for A with y being the input to A.

```
//Declaring and initializing all variables as integers

int P,Q,R,S,T,Y;

//the setup function runs once when you press reset or
power the board

void setup(){
pinMode(2,INPUT);
pinMode(3,INPUT);
pinMode(4,INPUT);
pinMode(5,INPUT);
pinMode(6,INPUT);
pinMode(13,OUTPUT);
}

//the loop function runs over and over again forever

void loop(){
P=digitalRead(2);
Q=digitalRead(3);
R=digitalRead(4);
S=digitalRead(5);
T=digitalRead(6);
Y=(!T&&P&&Q)||(P&&Q&&R&&S&&T);
digitalWrite(13,Y);
}
```

8. Execute the above code and compare the results of output theoretically and practically.