IMPLEMENTATION OF RANDOM GENERATOR USING D FLIP-FLOPS IN ARDUINO IDE

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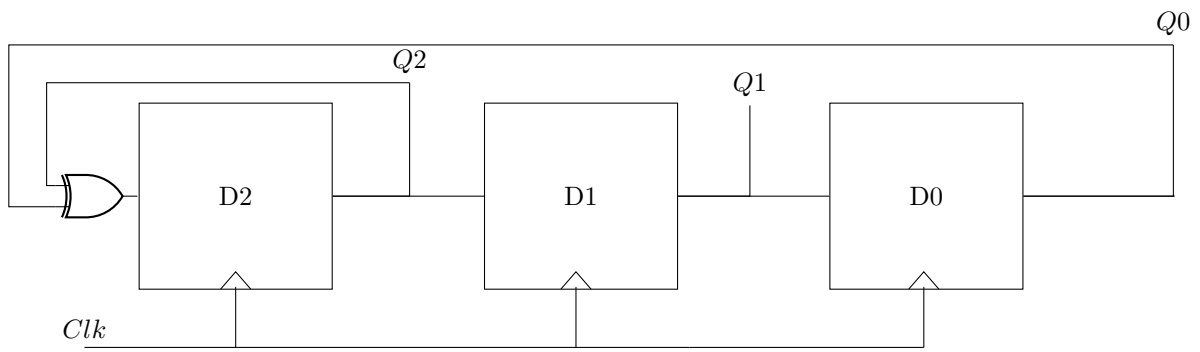
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1   Problem

(GATE2021-QP-EC)
Q.46 The propogation delay of the exclusive-OR(XOR) gate in the circuit in the figure is 3ns.The propogation delay of all the flip-flops is assumed to be zero.The clock(Clk) frequency provided to the circuit is 500MHz.

$Q0$

$Q2$

$Q1$

D2

D1

D0

Clk

Starting from the initial value of the flip-flop outputs $Q2Q1Q0 = 111$ with $D2 = 1$,the minimum number of triggering clock edges after which the flip-flop outputs $Q2Q1Q0$ becomes 1 0 0*(in integer)* is ___

2 Introduction

A random number generator using D flip-flops is a simple digital circuit that generates a sequence of random binary numbers.To implement this type of random number generator, we use a series of D flip-flops connected in a feedback loop. The output of each flip-flop is fed back into the input of the next flip-flop,creating a circuit that generated a sequence of random binary values.

The feedback loop creates a delay in the circuit,which causes the circuit to exhibit unpredictable behavior.This unpredictable behavior results in a sequence of random binary values. The length of the delay can be adjusted to control the randomness of the output.

3 Components

Table 1: Table1

Components	Value	Quantity
Breadboard		1
Resistor	$\geq 220\Omega$	1
Arduino	Uno	1
Seven Segment Display	Common Anode	1
Decoder	7447	1
Flip Flop	7474	2
Jumper Wires		20

3.1 Arduino

The Arduino Uno has some ground pins,analog input pins A0-A3 and digital pins D1-D13 that can be used for both input as well as output.It also has two power pins that can generate 3.3V and 5V.Inthe following exercises, we use digital pins,GND and 5V .

3.2 Seven Segment Display

The seven segment display has eight pins, a,b,c,d,e,f,g and dot that take an active LOW input,i.e. the LED will glow only if the input is connected to ground.Each of these pins is connected to an LED segment.The dot pin is reserved for the LED.

4 Implementation

A 7474 IC which has 14 pins and can store two seperate binary values.So we consider two IC's since we have three values and connect the D inputs of each flip-flop to the input signals of 7447 IC . Later interface 7447 IC to seven segment display for the output. The CLK input is used to trigger the flip-flop,and the Q output is used to read the stored value.When a positive edge is detected on the CLK input,the current value on the D input is stored in the flip-flop. The boolean expression of the D flip-flop is $Q(t+1) = D$

4.1 Truth table

Table 2: Table2

Present State			Flip-Flop input			Next State		
Q2	Q1	Q0	D2	D1	D0	Q2'	Q1'	Q0'
1	1	1	0	1	1	0	1	1
0	1	1	1	0	1	1	0	1
1	0	1	0	1	0	0	1	0
0	1	0	0	0	1	0	0	1
0	0	1	1	0	0	1	0	0
1	0	0	1	1	0	1	1	0
1	1	0	1	1	1	1	1	1

4.2   K-map

Since $Q' = D$,we find the k-maps for D as outputs

	$Q2\,Q1$			
	00	01	11	10
$Q0$ = 0	0	0	1	1
$Q0$ = 1	1	1	0	0

Figure 1: For $D2$

		00	01	11	10
				$Q2\ Q1$	
$Q0$	0	0	0	1	1
	1	0	0	1	1

Figure 2: For $D1$

$Q2\ Q1$

		00	01	11	10
	0	0	1	1	0
$Q0$	1	0	1	1	0

Figure 3: For $D0$

4.3 Boolean Equation

By solving the K-maps above we obtain as follows :

$$D2 = \overline{Q2}Q0 + \overline{Q0}Q2 \tag{1}$$
$$D1 = Q2 \tag{2}$$
$$D0 = Q1 \tag{3}$$

5 Hardware

1. Make the connections between the seven segment display and the 7447 IC as shown in Table3

Table 3: Table3

7447	$\overline{a}$	$\overline{b}$	$\overline{c}$	$\overline{d}$	$\overline{e}$	$\overline{f}$	$\overline{g}$
Display	a	b	c	d	e	f	g

2. Connect the Arduino,7447 and the two 7474 ICs according to Table4

Table 4: Table4

	INPUT			OUTPUT			CLOCK		5V			
	Q0	Q1	Q2	Q0'	Q1'	Q2'						
Arduino	D6	D7	D8	D2	D3	D4	D13					
7474	5	9		2	12		CLK1	CLK2	1	4	10	13
7474			5			2	CLK1	CLK2	1	4	10	13
7447				7	1	2			16			

3. Make the other D input pins of 7474 grounded and supply 5V and GND from the arduino as well.
4. When the clock edge is trigerred we observe display of random numbers.

6 Software

Now write the following code and upload in arduino to see the results.

```
#include<Arduino.h>

//Declaring all variables as integers

int D0,D1,D2,CLK;
int Q0,Q1,Q2;

//Creating a function

void ref(int D0,int D1,int D2,int CLK){
        digitalWrite(2,D0);
        digitalWrite(3,D1);
        digitalWrite(4,D2);
        digitalWrite(13,CLK);
}

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

void setup(){
        pinMode(2,OUTPUT);
        pinMode(3,OUTPUT);
        pinMode(4,OUTPUT);
        pinMode(13,OUTPUT);
        pinMode(6,INPUT);
        pinMode(7,INPUT);
        pinMode(8,INPUT);
}

//the loop function runs over and over again

void loop(){
        digitalWrite(13,HIGH);
        delay(1000);

        Q0=digitalRead(6);
        Q1=digitalRead(7);
        Q2=digitalRead(8);
        D2=(Q2&&!Q0) || (Q0&&!Q2);
        D1=(Q2);
        D0=(Q1);

        digitalWrite(13,LOW);

        ref(D0,D1,D2,CLK);
}
```