School of Computing
Faculty of Engineering
UNIVERSITI TEKNOLOGI MALAYSIA

SUBJECT : SECR1013 DIGITAL LOGIC

SESSION/SEM : 2020/2021 - SEM 1

LAB 3 : SYNCHRONOUS DIGITAL COUNTER

NAME : MUHAMMAD DINIE HAZIM BIN AZALI

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Lab #3

Identifying the Properties of a Synchronous Counter

A. Aims

1) Expose the student with experience on constructing synchronous counter circuit using Flip-Flop IC, Basic Gate ICs, Breadboard and ETS-5000 Digital Kit.
2) Promote critical thinking among students by analysing the given circuit and identifying the behaviour of the digital circuit.

B. Objectives

The objectives of this lab activity are to:

1) Implement a synchronous counter circuit into physical circuit using Breadboard, Flip-Flops, Basic Gates and Switches.
2) Completing the next-state table of the counter circuit.
3) Sketch the state diagram of the counter circuit.
4) Identify the properties of the counter.

C. Materials And Equipment

Materials and equipment required for this lab are as follows:

Item Name	Number of Item
1. Breadboard	1
2. 7408 Quad 2-Input AND	1
3. 7404 Hex Inverter	1
4. 7432 Quad 2-input OR	1
5. 7476 Dual J-K Flip Flop	1
6. ETS-5000 Digital Kit	1

D. Preliminary Works

1) Determine the logic level for each input combinations in Table 1 so that the desired result can be realized.

Table 1

Desired Result	PRE	CLR	J	K	CLK	Q
Set initial value Q = 1	0	1	X	X	--	1
Output Q stays the same	1	1	0	0	⇓	1
Output Q become 0, no change in asynchronous input	1	1	0	1	⇓	0
Output Q is not the previous Q	1	1	1	1	⇓	1
RESET Q	1	1	0	1	⇓	0
SET Q	1	1	1	0	⇓	1

2) Answer all questions.

a) Which state that JK flip-flop has, but not on SR flip-flop.

In JK flip-flop, the output will toggles if J=1 and K=1, however for SR flip-flop, the output will be invalid if S=1 and R=1.

b) Identify whether the JK flip flop in 7476, is a positive-edge triggered or negative-edge triggered flip flop.

JK flip-flop in 7476 is a negative-edge triggered flip-flop.

E. Lab Activities

1) You are given a counter circuit as shown in Figure 4.

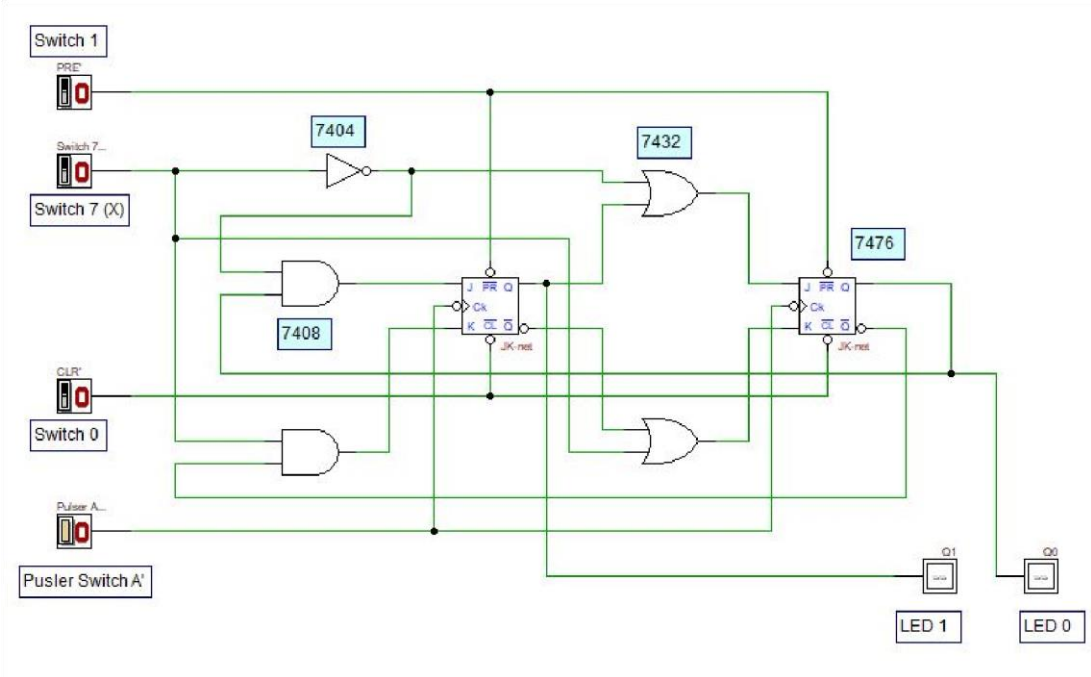


Figure 4: A Synchronous Counter Circuit

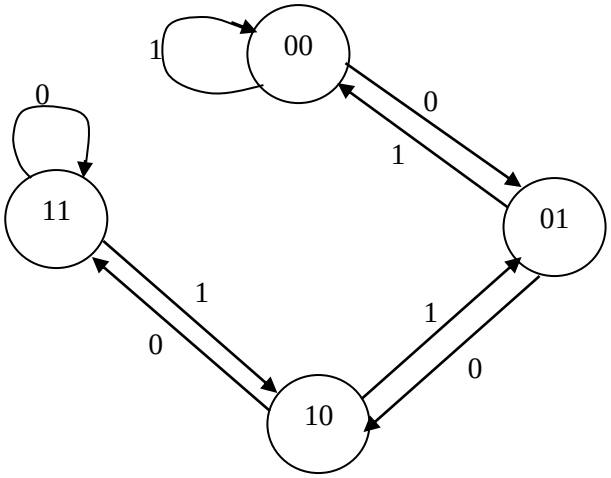
2) By using all materials and equipment's listed in section C, construct the physical circuit of Figure 4. (Make sure all ICs are connected to Vcc and GND).

3) Investigate the behaviour of the counter by observing the next state of the counter for all combination of *Present State* and *X* values. Complete the *NextState* table of the counter in Table 2. Ensure the Switch 0 is in HIGH state.
(0=LOW, 1=HIGH)

Table 2

Switch 7	Present State		Next State	
X	**Q1 LED 1**	**Q0 LED 0**	**Q1 LED 1**	**Q0 LED 0**
0	0	0	0	1
0	0	1	1	0
0	1	0	1	1
0	1	1	1	1
1	0	0	0	0
1	0	1	0	0
1	1	0	0	1
1	1	1	1	0

4) By referring to the *Next-State* in Table 2, sketch the state diagram of the counter.



5) By referring to the *Next-State* in Table 2 and the state diagram in (4), answer all questions.

a) What is the main indicator to decide that the counter is a synchronous counter?
All the flip-flops in the counter have the same clock.

b) How many states are available for the counter and what are they?
Four states are available which are 00, 01, 10, and 11.

c) What is the function of Switch 7 (X) in the circuit?
Switch 7 (X) is the clock signal in the circuit.

d) What is the function of Switch 0 and Switch 1 in the circuit?
Switch 0 is used to clear the counter while Switch 1 is used to set the counter.

e) Is the counter a saturated counter or recycle counter?
Saturated counter.

6) Referring to state diagram in 4, draw and built a synchronous counter using D flip-flop.

a) Built the next state and transition table using the header in Table 3

Table 3

Input X	Present State		Next State		D FF Transition	
	Q1	Q0	Q1+	Q0+	D1	D0
0	0	0	0	1	0	1
1	0	0	0	0	0	0
0	0	1	1	0	1	0
1	0	1	0	0	0	0
0	1	0	1	1	1	1
1	1	0	0	1	0	1
0	1	1	1	1	1	1
1	1	1	1	0	1	0

b) Get the optimized Boolean expression.

D_1

Q_1Q_0 / X	00	01	11	10
0	0	1	1	1
1	0	0	1	0

$D_1 = Q_0X' + Q_1X' + Q_1Q_0$

$= X'(Q_0 + Q_1) + Q_1Q_0$

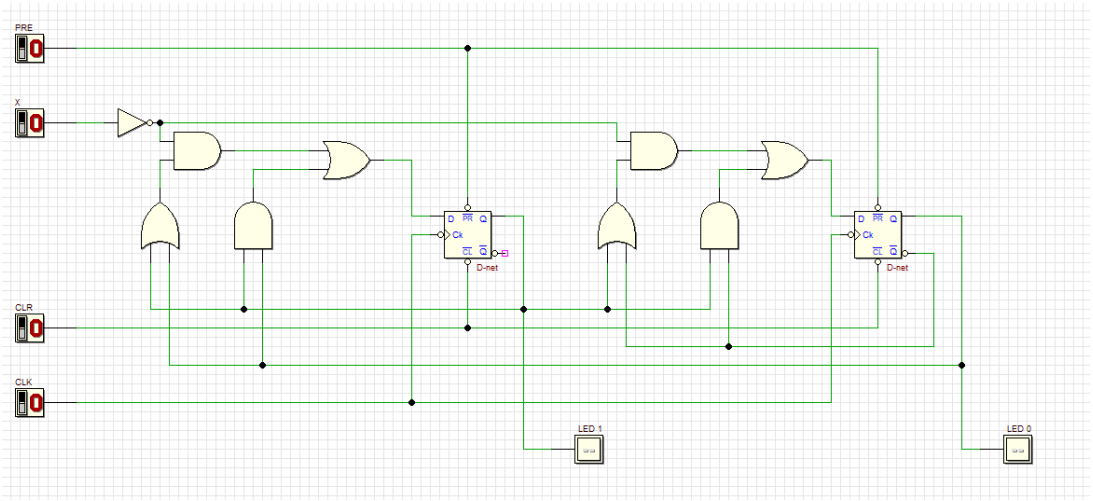
D_0

Q_1Q_0 / X	00	01	11	10
0	1	0	1	1
1	0	0	0	1

$D_0 = Q_1X' + Q_0'X' + Q_1Q_0'$

$= X'(Q_1 + Q_0') + Q_1Q_0'$

c) Draw the complete final circuit design in Deeds.



d) Simulate the circuit to prove that your Table 3 is correct.

7) Repeat steps in Q(6) using T flip-flop.

a)

Input	Present State		Next State		T FF Transition	
X	Q1	Q0	Q1+	Q0+	T1	T0
0	0	0	0	1	0	1
1	0	0	0	0	0	0
0	0	1	1	0	1	1
1	0	1	0	0	0	1
0	1	0	1	1	0	1
1	1	0	0	1	1	1
0	1	1	1	1	0	0
1	1	1	1	0	0	1

b)

T_1

Q_1Q_0 / X	00	01	11	10
0	0	1	0	0
1	0	0	0	1

$T_1 = Q_1'Q_0X' + Q_1Q_0'X$

T_0

Q_1Q_0 / X	00	01	11	10
0	1	1	0	1
1	0	1	1	1

$T_0 = Q_1X + Q_0'X' + Q_1'Q_0$

c)