ECE 204 - STATE MACHINES - INVESTIGATION 23
INTRODUCTION TO STATE MACHINES - PART I

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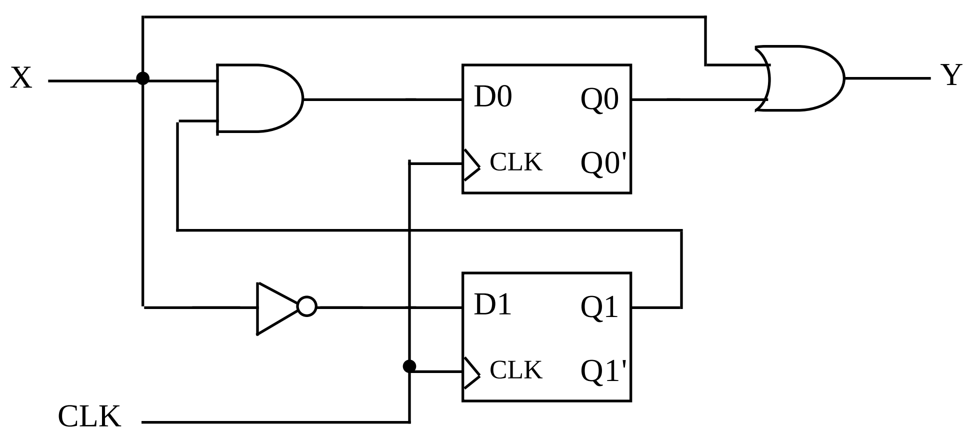
To do "well" on this investigation you must not only get the right answers but must also do neat, complete and concise writeups that make obvious what each problem is, how you're solving the problem and what your answer is. You also need to include drawings of all circuits as well as appropriate graphs and tables.

From the last Investigation we know how to design simple counters with the following algorithm

(1) Determine the next state table or state diagram
(2) Use the next state table or state diagram to obtain logic equations for the flip-flop inputs
(3) Realize the logic equations in part (2) with combinational logic

These counters are characterized by the fact that once they're built they always go in the same order from one state to the next after each clock pulse. Now these circuits are great for counting things like pills going into a bottle and for building digital watches. But most digital systems - everything from traffic light controllers to computers - also have inputs that play a role in determing their responses. We refer to digital systems with inputs and outputs as **state machines**. The objective of this and the next two Investigations is to introduce methods for analyzing and designing state machines.

1. A **state machine** like the following circuit

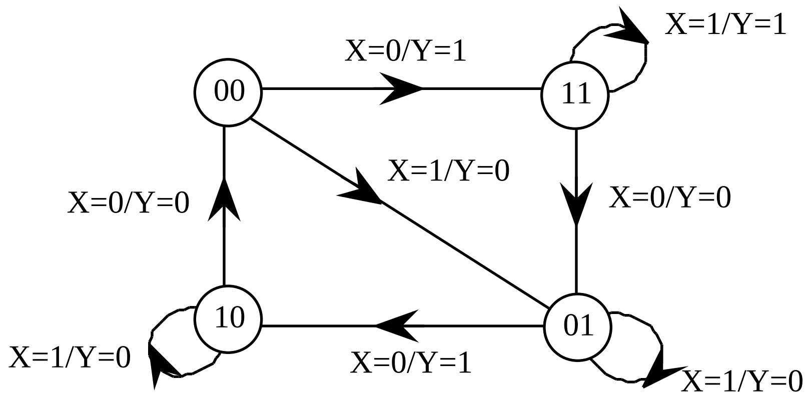


is a sequential circuit very much like a counter except it also has inputs X and outputs Y. And so the next state tables of state machines are going to have additional columns like the following

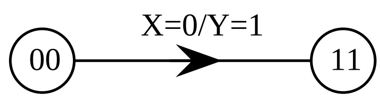
X	Q1	Q0	Y	Q1*	Q0*

Find the next state table for the state machine above. Hint - first find equations for Y, D1=Q1* and D0=Q0*. Note that your next state table should have 8 lines

2. State diagrams of state machines like the following



look very much like those of counters except they also contain the values of the inputs and outputs X and Y. For example



tells us that when we've in state Q_1Q_0=00 and the input is X=0 then the output is Y=1 and the next state is Q_1Q_0=11.

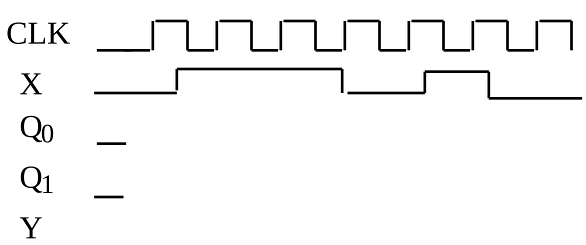
a. Find the next state table for the state diagram above
b. What do you expect we mean by the state of a state machine

3. How many states does a state machine with n flip-flops have

4. Given a state machine with the following next state table

X	**Q1**	**Q0**	**Y**	**Q1***	**Q0***
0	0	0	0	1	0
0	0	1	1	1	1
0	1	0	1	0	0
0	1	1	0	0	1
1	0	0	1	0	0
1	0	1	0	0	1
1	1	0	0	0	1
1	1	1	0	0	0

a. Draw the state diagram
b. Complete the following timing diagram



5. The objective of this problem is to design a state machine with the following next state table

X	**Q1**	**Q0**	**Y**	**Q1***	**Q0***
0	0	0	0	1	0
0	0	1	1	1	1
0	1	0	1	0	0
0	1	1	0	0	1
1	0	0	1	0	0
1	0	1	0	0	1
1	1	0	0	0	1
1	1	1	0	0	0

The procedure is basically the same as for synchronous counters.

a. First find equations for D1, D0 and Y as functions of X, Q1 and Q0 from the next state table with D1 and D0 inserted as follows

X	**Q1**	**Q0**	**D1**	**D0**	**Y**	**Q1***	**Q0***
0	0	0			0	1	0
0	0	1			1	1	1
0	1	0			1	0	0
0	1	1			0	0	1
1	0	0			1	0	0
1	0	1			0	0	1
1	1	0			0	0	1
1	1	1			0	0	0

b. Find equations for Y, Q1* and Q0*