<u>Designing Sequential Cirucits (Clock Cycle with D Flip Flop)</u>

What is a sequential circuit?

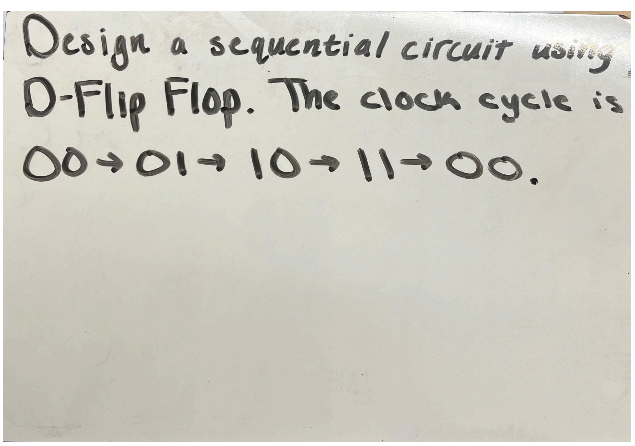
- Similar to combinational circuit in the set up BUT includes a clock cycle
- uses a type of Flip Flop in order to track the clock cycle
- For example a digital clock has a 12 hour cycle, it has a format of 00:00 and it cycles through each minute based on its programmed cycle

What is a D-Flip Flop

- The D in D Flip Flop stands for Delay
- This delay is necessary in a clock cycle because we must have a short delay in between parts in the cycle
- This allows for the clock to move to its next cycle
- For example in a digital clock when the clock goes from 11:00 to 11:01 it has a short delay in order to transition to that next minute

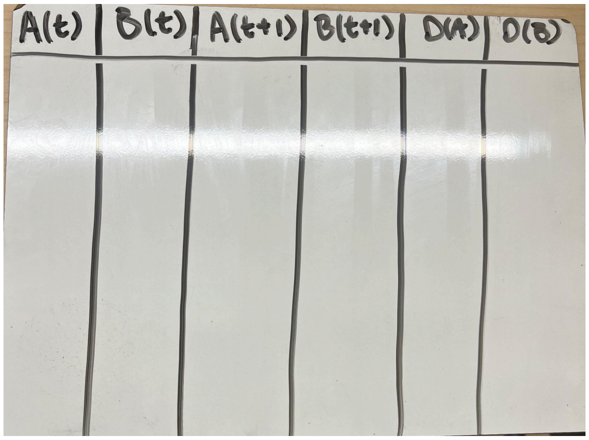
TO GO OVER BASIC SETUP FOR CIRCUITS FIND CIRCUIT GUIDE WORKSHEET

<u>Example</u>

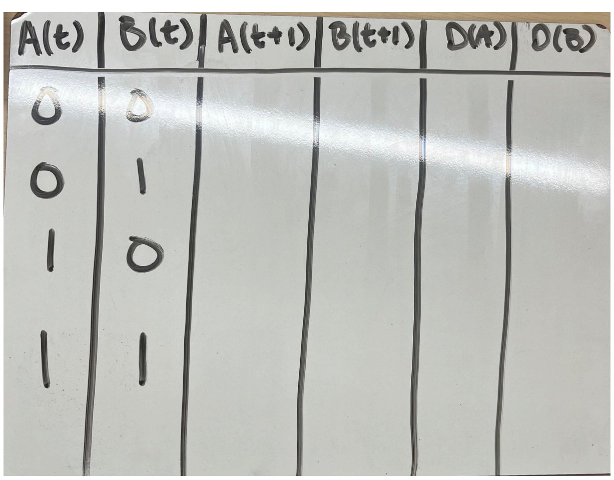


- Here we are told that we are using D-Flip Flop
- We given a cycle of two-bit numbers

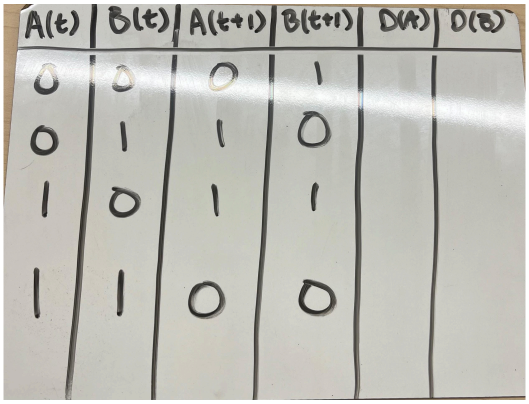
Create Truth Table



- When using a clock cycle we must label our inputs with (t)
- Because the clock cycle is in two-bit form, we need two inputs A(t) and B(t)
- When using any Flip Flop with a clock cycle you must have (t+1) rows for each input
- In this case we have A(t+1) and B(t+1)
- These (t+1) rows represent the next part of the clock cycle
- D() rows represent the D-Flip Flop rows and we can think of these as our output rows

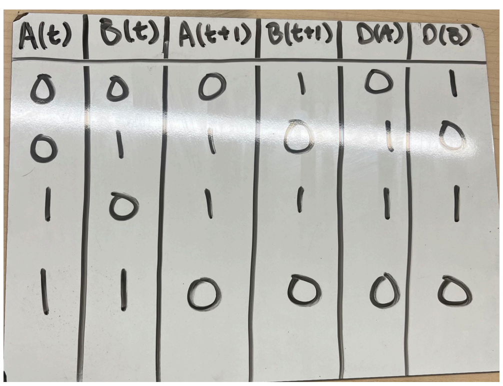


- Fill in our input rows based on the amount of bits we are using
- In this case, only two bits are needed for the given clock cycle in the prompt so we list out every possible formation of two-bits (00,01,10,11)



A(t)	B(t)	A(t+1)	B(t+1)	D(A)	D(B)
0	0	0	1		
0	1	1	0		
1	0	1	1		
1	1	0	0		

- Remember (t+1) represents the next part of the cycle
- Our cycle is 00->01->10->11->00
- So we look at our first case where A(t) and B(t) make up 00
- What comes after 00 in our cycle?.... It is 01
- This means in the first spot for our A(t+1) B(t+1) rows it will be 01
- After 01 is what…. 10
- After 10 is what…. 11
- After 11 is what…..00

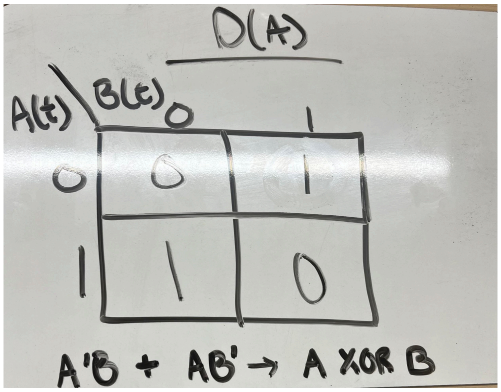


A(t)	B(t)	A(t+1)	B(t+1)	D(A)	D(B)
0	0	0	1	0	1
0	1	1	0	1	0
1	0	1	1	1	1
1	1	0	0	0	0

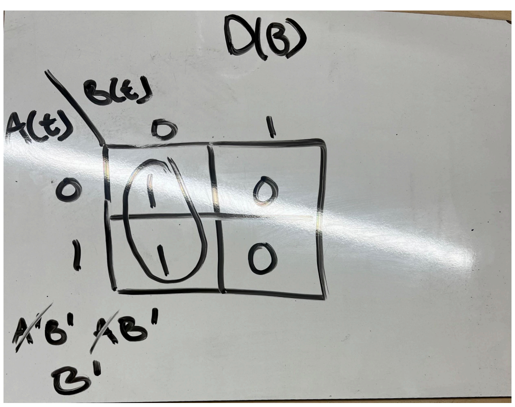
- When dealing with D-Flip Flop specfiically, the D() rows always match what is in the (t+1) rows
- As seen in this example it matches

Create K-Maps

- We need a k-map for each output our D(A) and D(B)



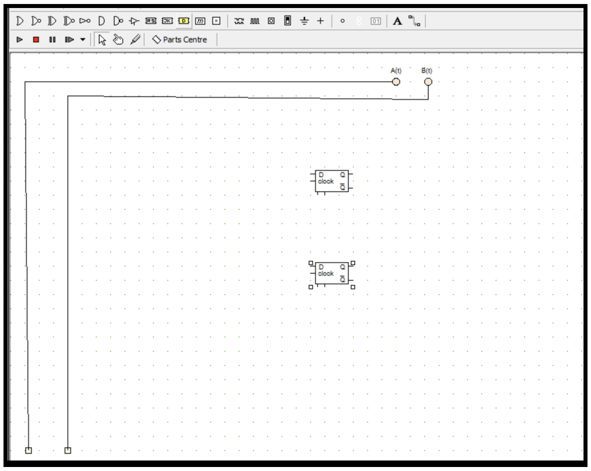
- Because we are dealing with a two bit we only need a 4 spot k-map
- When A(t) B(t) is 00 D(A) is 0 … fill in rest (refer to truth table)
- We then get the equation based on where we have 1's in the k-map
- There is a 1 at 01 (A'B) and a 1 at 10(AB')
- Our unsimplified equation is then A'B + AB'
- Cannot group because they are diagonal
- To simplify we keep what the equations have in common… BUT they are two bit and exact opposite from each other so we can simplify to A XOR B
- This means that this equation will be true if A or B is on



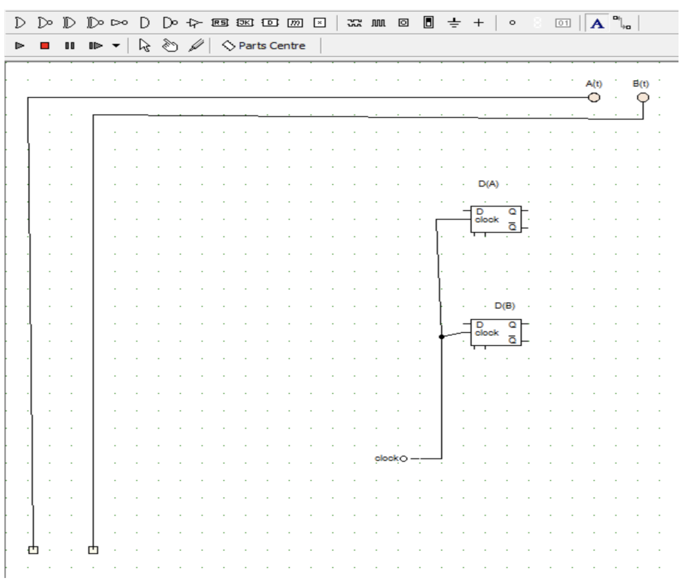
- When A(t)B(t) is 00 D(B) is 1 (refer to truth table)
- We get the equation based on where the 1's are in the k-map
- There is a 1 at 00(A'B') and there is a 1 at 10(AB')
- Our unsimplified equation is A'B' AB'
- We then simplify it by keeping whats in common
- The simplified equation is now B'

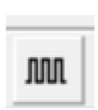
FOR BASIC SET UP IN DIGITAL WORKS SEE DIGITAL CIRCUITS GUIDE

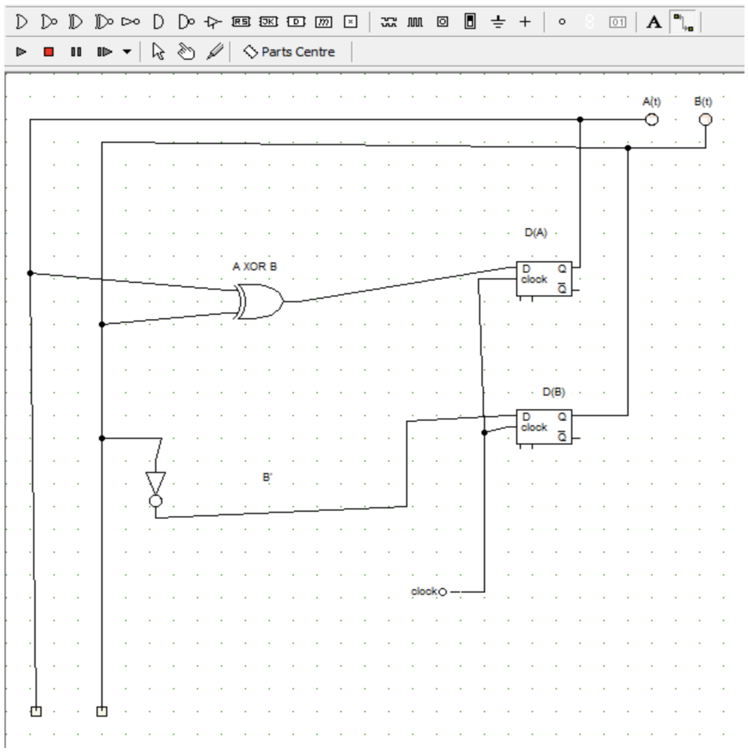
Draw in Digital Curucits



- First we need to draw our two inputs of A(t) and B(t)
- Because we are dealing with a clock cycle with no switches, we don' t need to add any buttons to our inputs
- Instead connect your input to an LED
- Then lay out your two D-Flip Flops

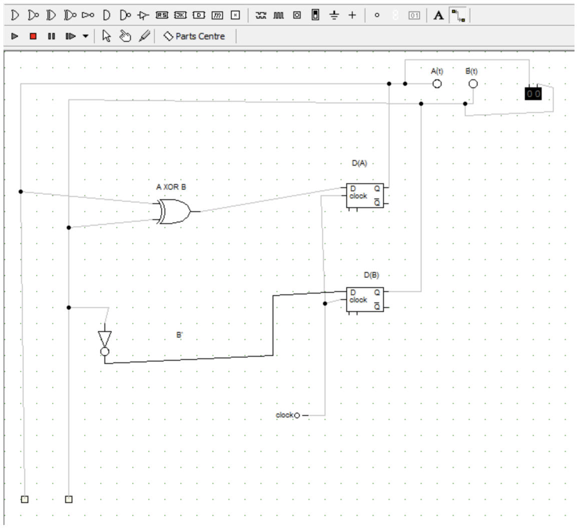


  - Then we click  ... this represents the clock that is seen in the circuit
  - Any time you have a clock cycle you will connect your flip flops to a clock
- Now connect your clock cycle
- This will allow your program to run a contoinuous cycle



- Now connect your equations to the related D-Flip Flops
- For our D(A) our equation was A XOR B so we select an XOR gate
- Connect A and B to the gate
- Connect the gate to the D part of the Flip Flop
- Our Equation for D(B) is B’
- Connect a not gate to B to access B’
- Connect B’ to the D part of the D(B) flip flop
- Connect the Q of your flip flop to its respective input
- IN this example D(A) is connected to A(t) and D(B) is connected to B(t)

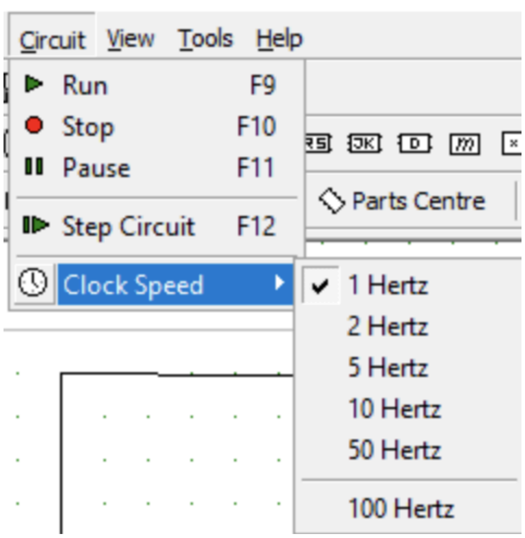
ALL DONE



- OPTIONAL
- You can select the icon 

- This is a binary converter, set to 2 bits and binary
- This will show the cycle in the format of the prompt for better understanding
- When you press play the cycle will run in the cycle shown in the prompt
- 00->01->10->11->00
- If press play and the cycle is going in the same order as the prompt then you did it right

If the cycle is going to fast

  - 

  - Change to 1hz this will slow it down

ALL DONE