ECE/CS 252
Intro to Computer Engineering

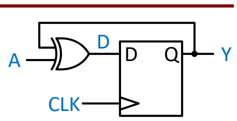
Week 05 Discussion

Sequential Circuits

- Include one or more flip-flops
- Have behavior that depends on more than just the current value of the circuit inputs
  - They need to "remember" some information about past behavior to know how to react to the input
  - To "remember", all of what has happened in the past must be encapsulated into <u>states</u>
    - You know whether you're happy or sad, but not why…
      - If you need to keep track of why, then you need multiple happy and sad states reflecting the different reasons
  - A state is defined by the current value in the flip-flops
    - Since the number of flip-flops must be finite, the number of possible states is also finite, hence the term FSM

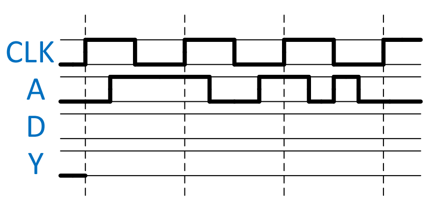
Sequential Circuit Waveform

- Complete the waveform for the sequential circuit shown at right, assuming signal Y is 0 at the start

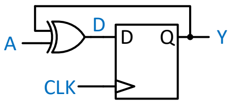


A	Y	D
0	0	0
0	1	1
1	0	1
1	1	0

Y	D
0	A
1	$\overline{A}$

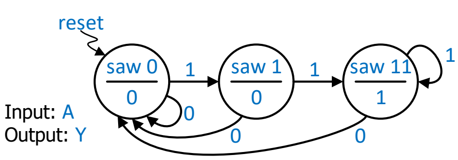


State Diagram



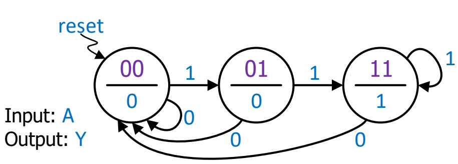
State Machines

- This state machine detects an input sequence of two 1s in a row
  - It outputs 1 when the two most recent inputs were 1
  - It outputs 0 otherwise

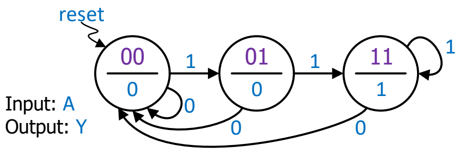


State Machine Analysis

- Before we do anything else, we'll assign a binary number to each state, such that each is unique
  - This would have to be done before implementing the state machine in hardware, but also makes our analysis easier…



State Machine Analysis



- What is/are the input signal(s)?
- What is/are the output signal(s)?
- What are the states?
- How many flip-flops do we need?

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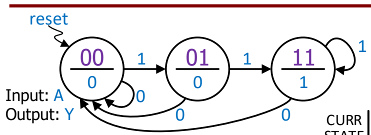
State Machine Analysis



- Complete the state table based on the diagram

CURR STATE	INPUT A	NEXT STATE	OUTPUT Y
0 0	0		
0 0	1		
0 1	0		
0 1	1		
1 0	0		
1 0	1		
1 1	0		
1 1	1		

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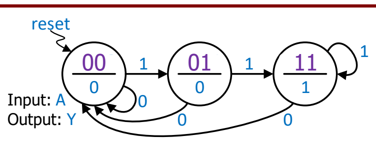
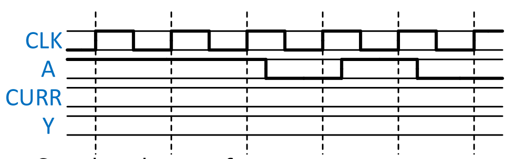
State Machine Analysis



- When will the output equal 1?



- Complete the waveform

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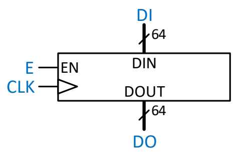
Registers

- Often want to operate on groups of bits



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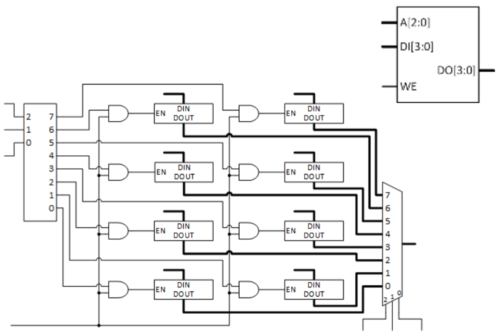
Logical View of Memory



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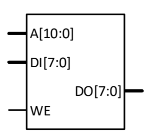
Memory Parameters

- How many address bits?
- How many unique address values?
- How many locations?
- How many bits per location?
- What is the word size?
- What is the memory's capacity?

- How do you write a location?

- How do you read a location?



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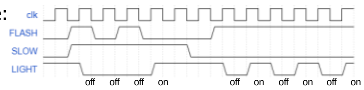
FSM Design

- Draw a state diagram for an FSM that will flash a light in two repeating sequences, OFF-ON-... or OFF-OFF-OFF-ON-... (i.e., ½ or ¼ time)
  - Inputs:
    - FLASH – flash light if 1, leave light ON constantly otherwise (always finish current flash sequence)
    - SLOW – flash ¼ time if 1, ½ time otherwise (ignore SLOW except when starting a flash sequence)
  - Output:
    - LIGHT – light is ON if 1, OFF if 0
  - Example:



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State Diagram

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Wrapping Up

- Up Next:
  - Basic Processor Model
  - von Neumann Compute Model
  - Instruction Processing
- Remember your videos and reading
  - Including the video quiz!
- Questions?

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