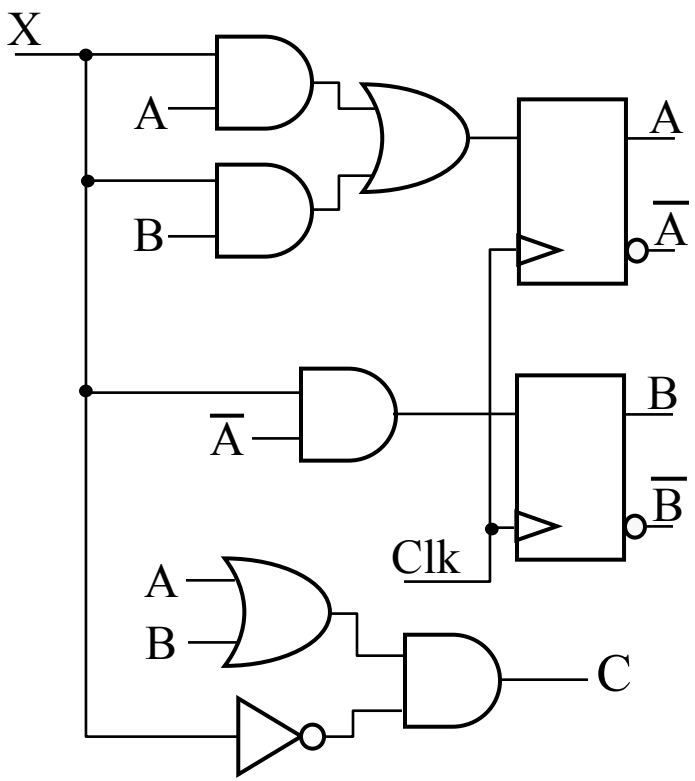
Sequential Logic Analysis

- Used to determine:
  - How a sequential logic circuit works
  - Given an initial state and and input sequence:
    - What will be the output sequence
    - What will be the final state
  - Logic simulation cannot always do this
    - Unless initial state can be set
- The opposite procedure of design
  1. Start with circuit diagram
  2. Derive output equations
  3. Derive flip-flop input equations
  4. Derive state table
  5. Derive state diagram

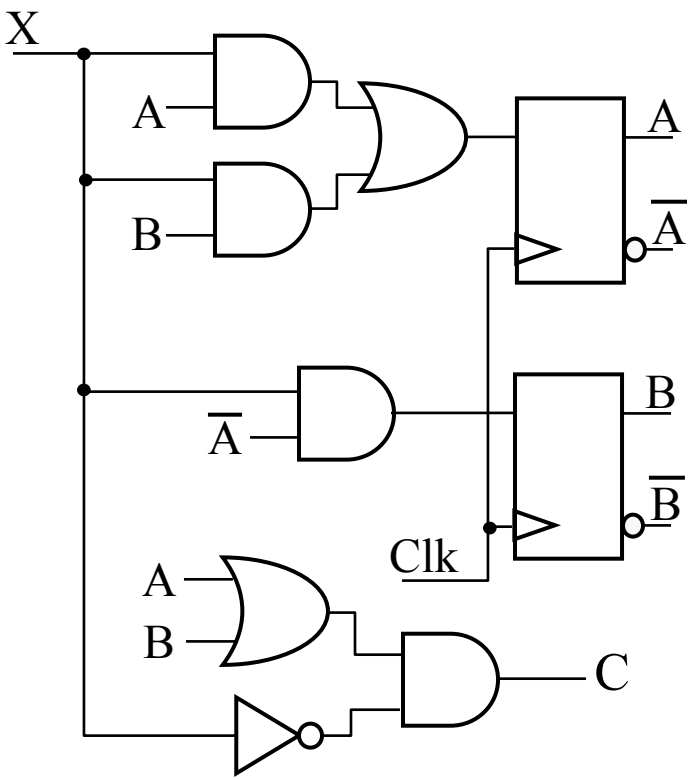
Analysis Example

- Given this sequential logic circuit and:
  - An initial state of A=0 & B=1
  - An input sequence X=010011
- What will be the final state?
- What will be the output sequence?



Analysis Example

- From logic diagram obtain logic equations:
  - $C = X'(A+B) = AX' + BX'$
  - $D_A = AX + BX$
    - $A^+ = D_A$ (for D flip-flop)
  - $D_B = A'X$
    - $B^+ = D_B$ (for D flip-flop)
- Next obtain state table then state diagram

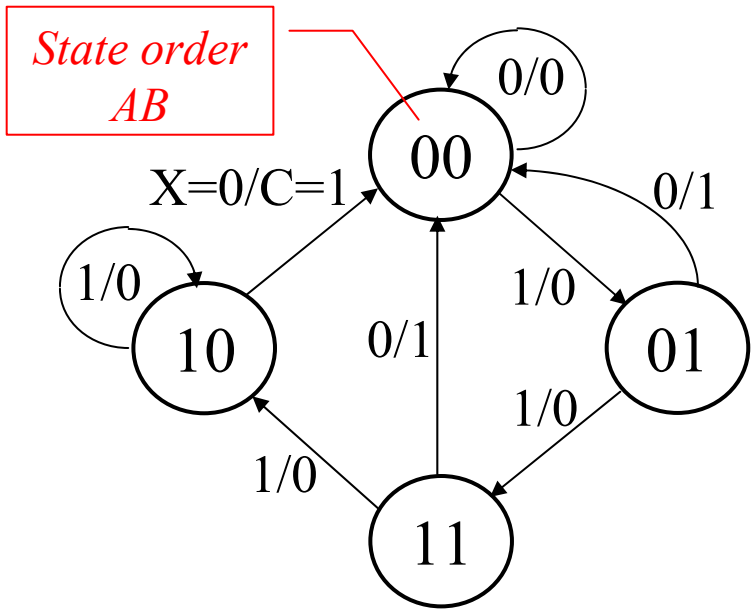


Analysis Example (continued)

$C = X'(A+B) = AX' + BX'$

$A^+ = AX + BX$

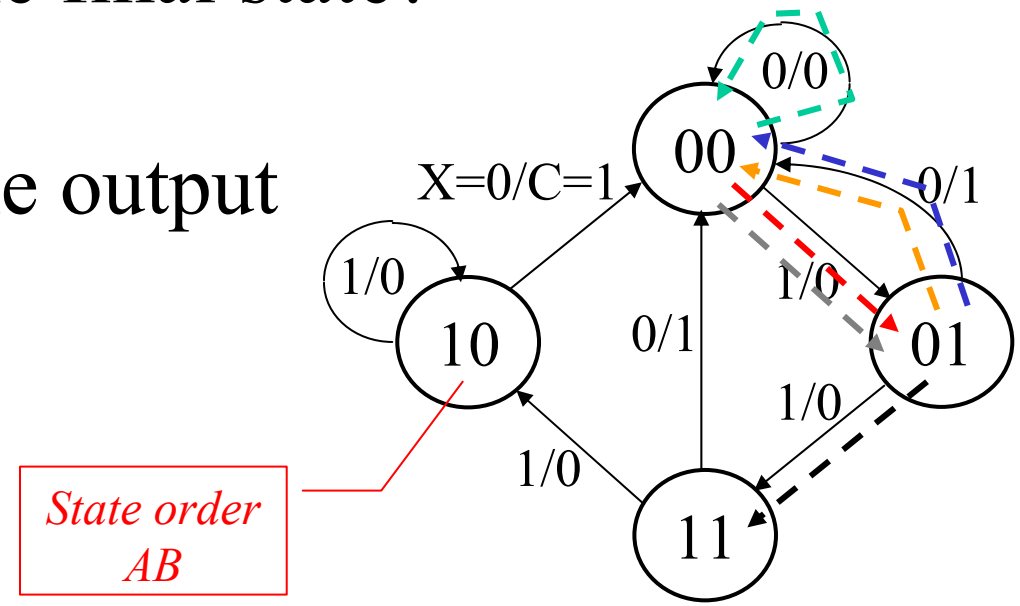
$B^+ = A'X$



Input	Current State	Next State	Output
X	A B	A^+ B^+	C
0	0 0	0 0	0
1	0 0	0 1	0
0	0 1	0 0	1
1	0 1	1 1	0
0	1 0	0 0	1
1	1 0	1 0	0
0	1 1	0 0	1
1	1 1	1 0	0

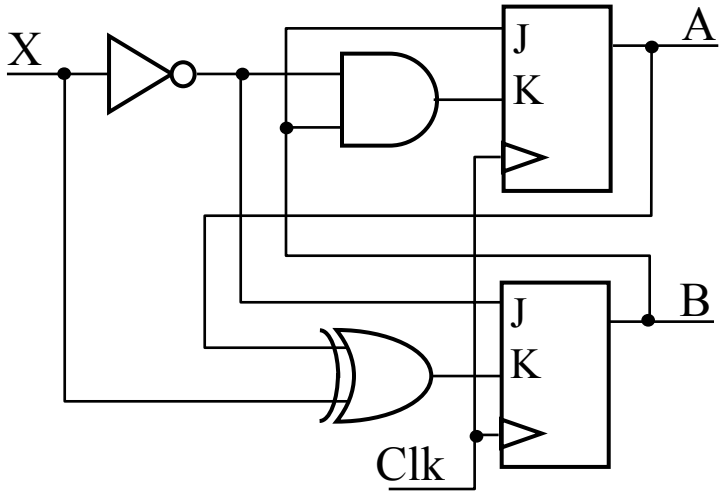
Analysis Example (continued)

- Given:
  - An initial state of A=0 & B=1
  - An input sequence X=010011
- What will be the final state?
  - A=1 & B=1
- What will be the output sequence?
  - X=010011
  - C=101000



Another Analysis Example

- The characteristic equation for D flip-flops makes analysis a little easier than other flip-flops
- Consider this circuit with JK flip-flops
  - Here we assume that A and B are the circuit outputs



Equations for inputs to FFs:

$J_A = B$

$K_A = BX'$

$J_B = X'$

$K_B = A \oplus X = AX' + A'X$

JKFF Analysis Example

- Fill in inputs and current state as usual
- Evaluate FF inputs based on inputs and current state
- Use characteristic table to obtain next state from FF inputs

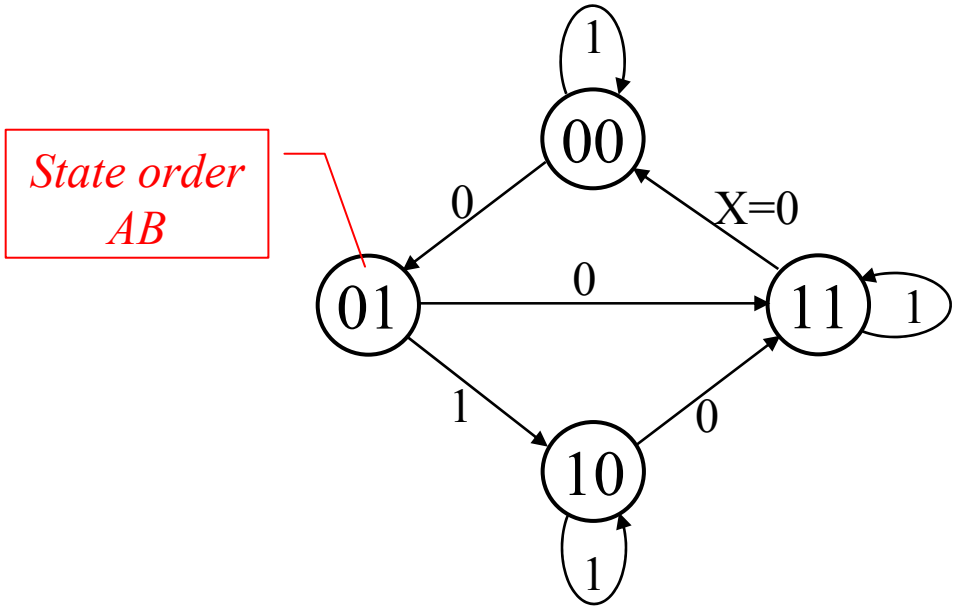
Input X	Current State A B	A FF inputs J_A K_A	B FF inputs J_B K_B	Next State A^+ B^+
0	0 0	0 0	1 0	0 1
1	0 0	0 0	0 1	0 0
0	0 1	1 1	1 0	1 1
1	0 1	1 0	0 1	1 0
0	1 0	0 0	1 1	1 1
1	1 0	0 0	0 0	1 0
0	1 1	1 1	1 1	0 0
1	1 1	1 0	0 0	1 1

JK FF characteristic table

J	K	Q+
0	0	Q
0	1	0
1	0	1
1	1	Q’

JKFF Analysis Example (continued)

- Now obtain state diagram from state table
  - Based on inputs, current state, and next state
- Now we can analyze circuit behavior
  - Based on initial state and input sequence



Input X	Current State A B	Next State A^+ B^+
0	0 0	0 1
1	0 0	0 0
0	0 1	1 1
1	0 1	1 0
0	1 0	1 1
1	1 0	1 0
0	1 1	0 0
1	1 1	1 1