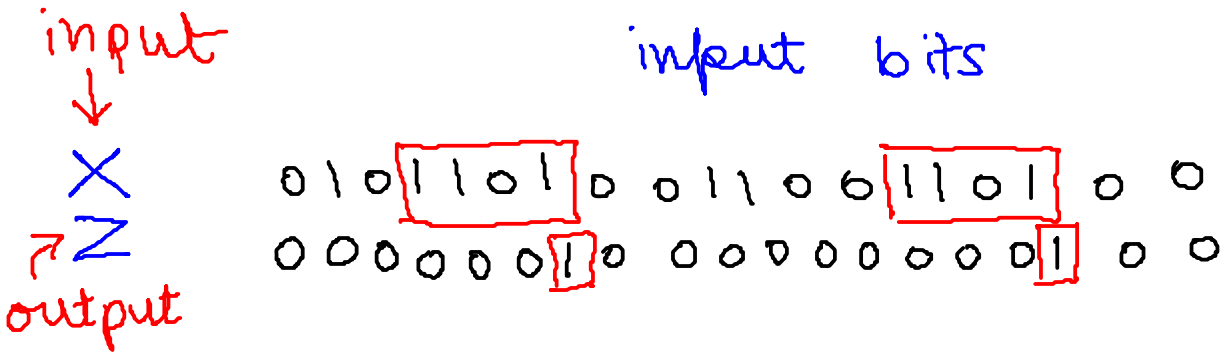
Sequential Circuit Design

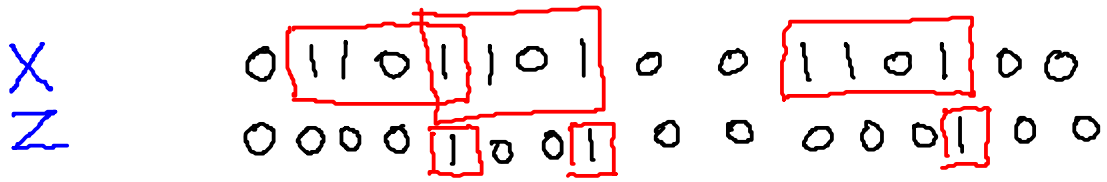
1. Specification – written specification
2. Formulation – State diagram → table
3. State Assignment – Assign Binary codes to States
4. Flip-Flop input equations determination
5. Output equation determination
6. Optimization – K-maps
7. Technology Mapping - circuit
8. Verification – Simulation

Example Sequence Recognizer

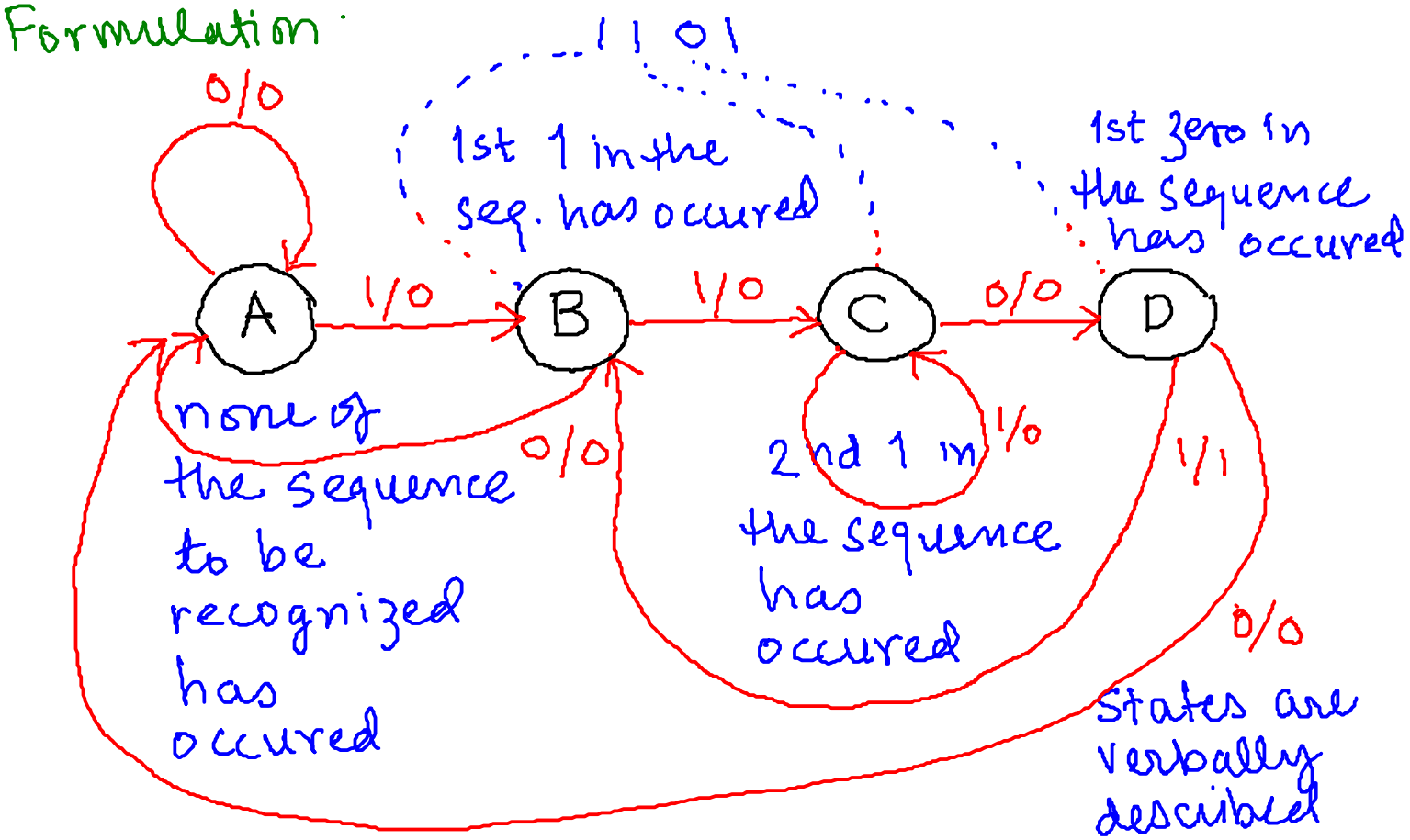
Specification: Recognize the sequence 1101 in a stream of input bits



Mealy



Formulation



State table

Present State	Next State X=0	Next State X=1	Output Z X=0	Output Z X=1
A	A	B	0	0
B	A	C	0	0
C	D	C	0	0
D	A	B	0	1

State Assignment Assign Binary Codes to states

	Present State A	Present State B	Next State X=0		Next State X=1		Output Z X=0	Output Z X=1
Binary	0	0	0	0	0	1	0	0
Gray Code	0	1	0	0	1	1	0	0
	1	1	1	0	1	1	0	0
	1	0	0	0	0	1	0	1

4- Flip Flop Input Equations

$$A^+ = D_A(A, B, X) = \sum m(?)$$

$$B^+ = D_B(A, B, X) = \sum m(?)$$

5- Output Equation

$$Z(A, B, X) = \sum m(?)$$

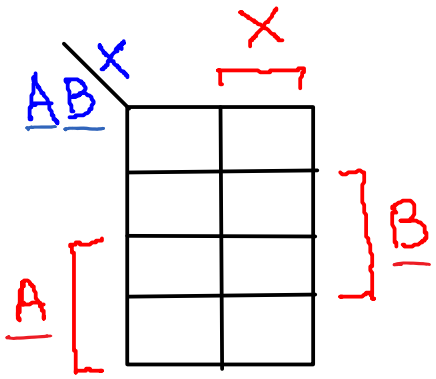
	A	B	X	A^+ D_A	B^+ D_B	Z
m_0	0	0		0	0	0
m_1	0	0		0	1	0
m_2	0	1		0	0	0
m_3	0	1		1	1	0
m_4	1	0		0	0	0
m_5	1	0		0	1	1
m_6	1	1		1	0	0
m_7	1	1		1	1	0

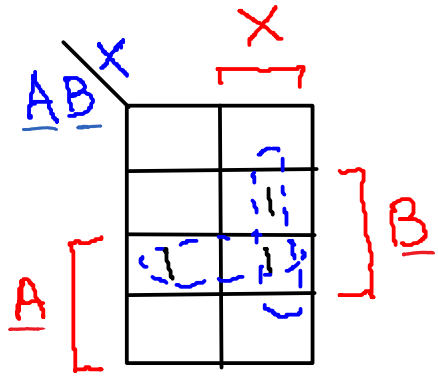
$$D_A(A, B, X) = \sum m(3, 6, 7)$$

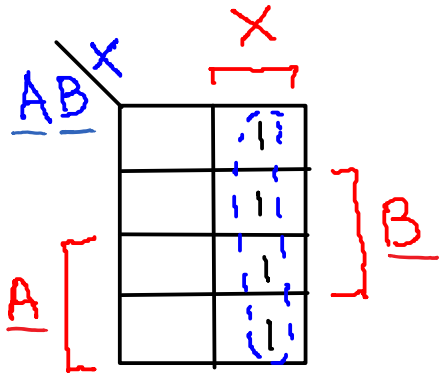
$$D_B(A, B, X) = \sum m(1, 3, 5, 7)$$

$$Z(A, B, X) = \sum m(5)$$

AB \ X	0	1
00	m_0	m_1
01	m_2	m_3
11	m_6	m_7
10	m_4	m_5



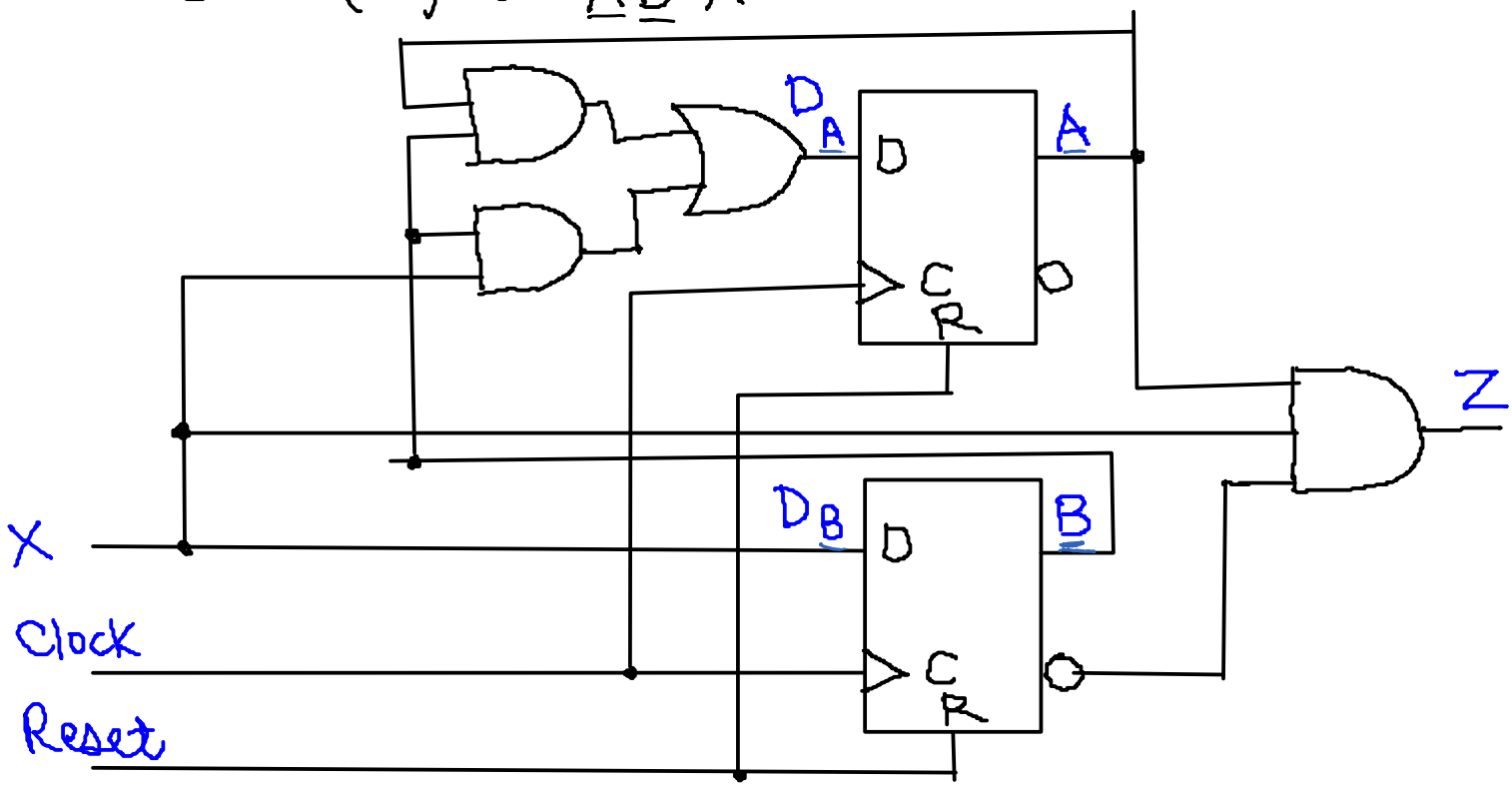




$D_A = A\bar{B} + \bar{B}X$

$D_B = X$

$Z = m(5) = A\bar{B}X$



Unused states

n flip-flops → 2^n possible states

unused states if # of states $< 2^n$

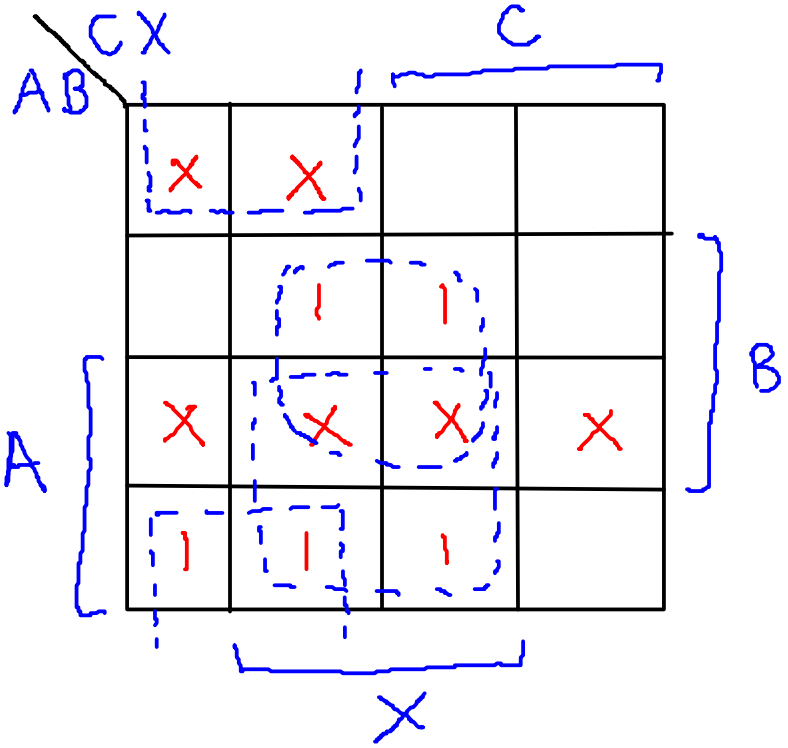
Example.

Present State			Input	Next State		
A	B	C	X	A	B	C
0	0	1	0	0	0	1
0	0	1	1	0	1	0
0	1	0	0	0	1	1
0	1	0	1	1	0	0
0	1	1	0	0	0	1
0	1	1	1	1	0	0
1	0	0	0	1	0	1
1	0	0	1	1	0	0
1	0	1	0	0	0	1
1	0	1	1	1	0	0

Three unused states 000 110 111
Six missing rows

prob. 1 (a) Draw the State Diagram

Simplify by using K-maps and dont care minterms



K-Map for D_A

$$D_A = AX + BX + \overline{B}\,\overline{C}$$

$$D_B = \overline{A}\,\overline{C}\,X + \overline{A}\,\overline{B}\,X$$

$$D_C = \overline{X}$$

Prob. 1(b): Use K maps to derive these

Prob. 1(c) Draw the Circuit