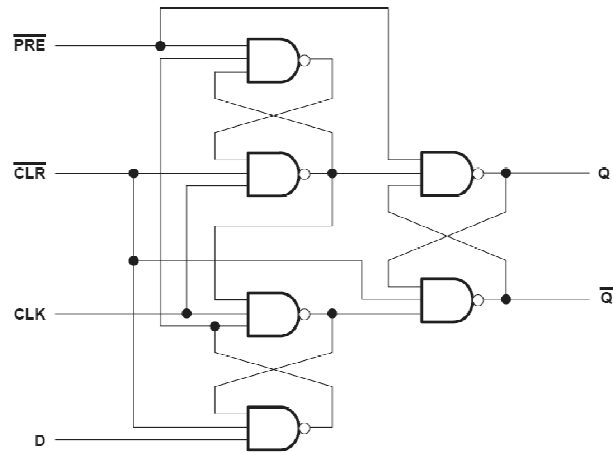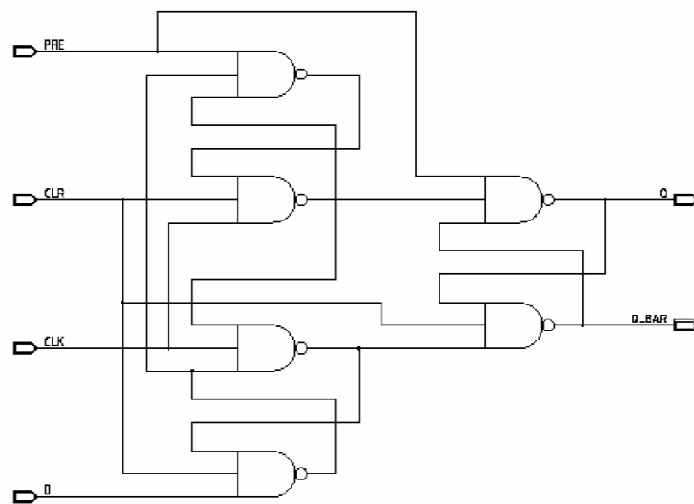# Asynchronous Design Technique in Reverse ➔ Analysis

Analysis Technique

- Reverse order for analysis
- Start with logic diagram
- Generate equations
- Put equations in K-Map (Final State Table)
- Determine stable, unstable states
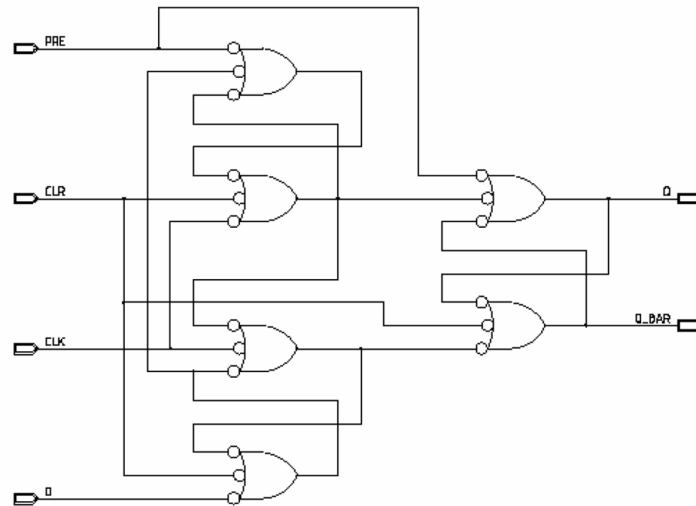- Generate State Diagram
- Determine behavior

SN7474 – D-FlipFlop

Cleaned Up Schematic

Cleaned Up Schematic (DeMorgan)

Don't Worry About Cross Coupled Outs

And Generate Equations

$$W = \overline{Z} + \overline{X}$$

$$X = \overline{W} + \overline{CLK}$$

$$Y = \overline{X} + \overline{CLK} + \overline{Z}$$

$$Z = \overline{D} + \overline{Y}$$

From Equations – K-Maps

Patterns for Logic Areas in Map

D CLK W X Y Z

So, Map for W

not X or not Z → W

$$W = \overline{Z} + \overline{X}$$

Put W in the Map

			D	
0000	1 - - -	1 - - -	1 - - -	1 - - -
0001	1 - - -	1 - - -	1 - - -	1 - - -
0011	1 - - -	1 - - -	1 - - -	1 - - -
0010	1 - - -	1 - - -	1 - - -	1 - - -
0110	1 - - -	1 - - -	1 - - -	1 - - -
0111	0 - - -	0 - - -	0 - - -	0 - - -
0101	0 - - -	0 - - -	0 - - -	0 - - -
0100	1 - - -	1 - - -	1 - - -	1 - - -
1100	1 - - -	1 - - -	1 - - -	1 - - -
1101	0 - - -	0 - - -	0 - - -	0 - - -
1111	0 - - -	0 - - -	0 - - -	0 - - -
1110	1 - - -	1 - - -	1 - - -	1 - - -
1010	1 - - -	1 - - -	1 - - -	1 - - -
1011	1 - - -	1 - - -	1 - - -	1 - - -
1001	1 - - -	1 - - -	1 - - -	1 - - -
1000	1 - - -	1 - - -	1 - - -	1 - - -

X W Y Z CK

And, Map for X

not W   or   not CLK   →   X

$$X = \overline{W} + \overline{CLK}$$

4/25/2011

Add X to the W Map

	D			
0000	1 1 - -	1 1 - -	1 1 - -	1 1 - -
0001	1 1 - -	1 1 - -	1 1 - -	1 1 - -
0011	1 1 - -	1 1 - -	1 1 - -	1 1 - -
0010	1 1 - -	1 1 - -	1 1 - -	1 1 - -
0110	1 1 - -	1 1 - -	1 1 - -	1 1 - -
0111	0 1 - -	0 1 - -	0 1 - -	0 1 - -
0101	0 1 - -	0 1 - -	0 1 - -	0 1 - -
0100	1 1 - -	1 1 - -	1 1 - -	1 1 - -
1100	1 1 - -	1 0 - -	1 0 - -	1 1 - -
1101	0 1 - -	0 0 - -	0 0 - -	0 1 - -
1111	0 1 - -	0 0 - -	0 0 - -	0 1 - -
1110	1 1 - -	1 0 - -	1 0 - -	1 1 - -
1010	1 1 - -	1 0 - -	1 0 - -	1 1 - -
1011	1 1 - -	1 0 - -	1 0 - -	1 1 - -
1001	1 1 - -	1 0 - -	1 0 - -	1 1 - -
1000	1 1 - -	1 0 - -	1 0 - -	1 1 - -
	CK			

(Row-group labels: X, W on the left; Y, Z on the right)

Now, Map for Y

not X   or   not CLK   or   not Z   →   Y

$$Y = \overline{X} + \overline{CLK} + \overline{Z}$$

Add Y to the W,X Map

	D			
0000	1 1 1 -	1 1 1 -	1 1 1 -	1 1 1 -
0001	1 1 1 -	1 1 1 -	1 1 1 -	1 1 1 -
0011	1 1 1 -	1 1 1 -	1 1 1 -	1 1 1 -
0010	1 1 1 -	1 1 1 -	1 1 1 -	1 1 1 -
0110	1 1 1 -	1 1 1 -	1 1 1 -	1 1 1 -
0111	0 1 1 -	0 1 0 -	0 1 0 -	0 1 1 -
0101	0 1 1 -	0 1 0 -	0 1 0 -	0 1 1 -
0100	1 1 1 -	1 1 1 -	1 1 1 -	1 1 1 -
1100	1 1 1 -	1 0 1 -	1 0 1 -	1 1 1 -
1101	0 1 1 -	0 0 0 -	0 0 0 -	0 1 1 -
1111	0 1 1 -	0 0 0 -	0 0 0 -	0 1 1 -
1110	1 1 1 -	1 0 1 -	1 0 1 -	1 1 1 -
1010	1 1 1 -	1 0 1 -	1 0 1 -	1 1 1 -
1011	1 1 1 -	1 0 1 -	1 0 1 -	1 1 1 -
1001	1 1 1 -	1 0 1 -	1 0 1 -	1 1 1 -
1000	1 1 1 -	1 0 1 -	1 0 1 -	1 1 1 -

X, W, Y, Z, CK

Finally, Map for Z

not D   or   not Y   →   Z

$$Z = \overline{D} + \overline{Y}$$

And At Last, Add Z to the W,X,Y Map

	D			
0000	1111	1111	1111	1111
0001	1111	1111	1111	1111
0011	1111	1111	1110	1110
0010	1111	1111	1110	1110
0110	1111	1111	1110	1110
0111	0111	0101	0100	0110
0101	0111	0101	0101	0111
0100	1111	1111	1111	1111
1100	1111	1011	1011	1111
1101	0111	0001	0001	0111
1111	0111	0001	0000	0110
1110	1111	1011	1010	1110
1010	1111	1011	1010	1110
1011	1111	1011	1010	1110
1001	1111	1011	1011	1111
1000	1111	1011	1011	1111

CK

Identify the Stable States

	D			
0000	1111	1111	1111	1111
0001	1111	1111	1111	1111
0011	1111	1111	1110	1110
0010	1111	1111	1110	1110
0110	1111	1111	1110	1110
0111	[0111]	0101	0100	0110
0101	0111	[0101]	[0101]	0111
0100	1111	1111	1111	1111
1100	1111	1011	1011	1111
1101	0111	0001	0001	0111
1111	0111	0001	0000	0110
1110	1111	1011	1010	[1110]
1010	1111	1011	[1010]	1110
1011	1111	[1011]	1010	1110
1001	1111	1011	1011	1111
1000	1111	1011	1011	1111

CK

Situation 1: D Stays Low, CK Up,Down

	D			
0000	1111	1111	1111	1111
0001	1111	1111	1111	1111
0011	1111	1111	1110	1110
0010	1111	1111	1110	1110
0110	1111	1111	1110	1110
0111	0111	0101	0100	0110
0101	0111	0101	0101	0111
0100	1111	1111	1111	1111
1100	1111	1011	1011	1111
1101	0111	0001	0001	0111
1111	0111	0001	0000	0110
1110	1111	1011	1010	1110
1010	1111	1011	1010	1110
1011	1111	1011	1010	1110
1001	1111	1011	1011	1111
1000	1111	1011	1011	1111

CK

Situation 2: CK Stays Low, D Up, Down

	D			
0000	1111	1111	1111	1111
0001	1111	1111	1111	1111
0011	1111	1111	1110	1110
0010	1111	1111	1110	1110
0110	1111	1111	1110	1110
0111	0111	0101	0100	0110
0101	0111	0101	0101	0111
0100	1111	1111	1111	1111
1100	1111	1011	1011	1111
1101	0111	0001	0001	0111
1111	0111	0001	0000	0110
1110	1111	1011	1010	1110
1010	1111	1011	1010	1110
1011	1111	1011	1010	1110
1001	1111	1011	1011	1111
1000	1111	1011	1011	1111

CK

Situation 3: CK High, D Up,Down

D →

			D	
0000	1111	1111	1111	1111
0001	1111	1111	1111	1111
0011	1111	1111	1110	1110
0010	1111	1111	1110	1110
0110	1111	1111	1110	1110
0111	0111	0101	0100	0110
0101	0111	0101	0101	0111
0100	1111	1111	1111	1111
1100	1111	1011	1011	1111
1101	0111	0001	0001	0111
1111	0111	0001	0000	0110
1110	1111	1011	1010	1110
1010	1111	1011	1010	1110
1011	1111	1011	1010	1110
1001	1111	1011	1011	1111
1000	1111	1011	1011	1111

X, W (left) ; Y, Z (right) ; CK (bottom)

Situation 3A: CK High, D Up,Down

			D	
0000	1111	1111	1111	1111
0001	1111	1111	1111	1111
0011	1111	1111	1110	1110
0010	1111	1111	1110	1110
0110	1111	1111	1110	1110
0111	0111	0101	0100	0110
0101	0111	0101	0101	0111
0100	1111	1111	1111	1111
1100	1111	1011	1011	1111
1101	0111	0001	0001	0111
1111	0111	0001	0000	0110
1110	1111	1011	1010	1110
1010	1111	1011	1010	1110
1011	1111	1011	1010	1110
1001	1111	1011	1011	1111
1000	1111	1011	1011	1111

X, W (left) ; Y, Z (right) ; CK (bottom)

Situation 4: D High, CK Up, Down

	|← D →|			
0000	1111	1111	1111	1111
0001	1111	1111	1111	1111
0011	1111	1111	1110	1110
0010	1111	1111	1110	1110
0110	1111	1111	1110	1110
0111	[0111]	0101	0100	0110
0101	0111	[0101]	[0101]	0111
0100	1111	1111	1111	1111
1100	1111	1011	1011	1111
1101	0111	0001	0001	0111
1111	0111	0001	0000	0110
1110	1111	1011	1010	[1110]
1010	1111	1011	[1010]	1110
1011	1111	[1011]	1010	1110
1001	1111	1011	1011	1111
1000	1111	1011	1011	1111

X, Y, Z, W bracketing labels; CK across columns.

So – Name States, Make Diagram

	|← D →|			
0000	1111	1111	1111	1111
0001	1111	1111	1111	1111
0011	1111	1111	1110	1110
0010	1111	1111	1110	1110
0110	1111	1111	1110	1110
0111	(A)	0101	0100	0110
0101	0111	(B)	(C)	0111
0100	1111	1111	1111	1111
1100	1111	1011	1011	1111
1101	0111	0001	0001	0111
1111	0111	0001	0000	0110
1110	1111	1011	1010	(D)
1010	1111	1011	(E)	1110
1011	1111	(F)	1010	1110
1001	1111	1011	1011	1111
1000	1111	1011	1011	1111

X, Y, Z, W bracketing labels; CK across columns.

State Diagram

States: F, A, B, E, D, C

Transition labels (input/output):

- F self-loop: $\frac{01}{01}$
- A self-loop: $\frac{00}{11}$
- B self-loop: $\frac{01}{10}$
- E self-loop: $\frac{11}{01}$
- C self-loop: $\frac{11}{10}$
- D self-loop: $\frac{10}{11}$
- A → B: $\frac{01}{10}$
- F → A
- F ↔ E: $\frac{01}{01}$, $\frac{11}{01}$
- A ↔ D: $\frac{00}{11}$, $\frac{10}{11}$
- B ↔ A: $\frac{00}{11}$
- B ↔ C: $\frac{01}{10}$, $\frac{11}{10}$
- E ↔ D: $\frac{10}{11}$, $\frac{11}{01}$
- C → D: $\frac{10}{11}$