Lecture # 12

Counters

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$$\Rightarrow \quad \uparrow \quad \rightsquigarrow \quad Q_{n+1} = D$$

Otherwise $\rightsquigarrow Q_{n+1} = Q_n$

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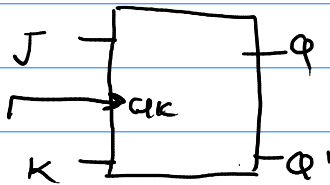
J	K	Q_{n+1}
0	0	No Change
0	1	0
1	0	1
1	1	$\overline{Q_n}$

\#
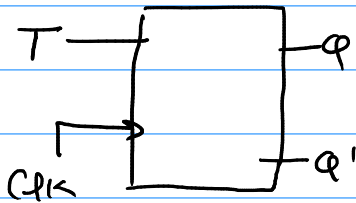
T	Q_{n+1}
0	Q_n
1	$\overline{Q_n}$

7 6 5 4 3   2 1 0

1 1 0 1 1 0 1 1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	1	0	1	1	0	1	1

$D =$ Q_A Q_B

A B

Q' Q'

Clk   Clk

D

Q_A

Q_B

0	0	0	0

$\uparrow$ $\downarrow$

r   0   ①   0

0   0   0

Q_D — D_D — Q_C D_C — Q_B D_B — ϕ — Q_A D_A A

Clk

| 0 | 0 | 0 | 1 | 0

after 1 clk pulse edge $\uparrow$

| 0 | 0 | 1 | 0 | → 1

2nd clk edge ⊓ $\downarrow$

| 0 | 1 | 0 | 1 |

→ 3rd clk $\uparrow$

| 1 | 0 | 1 | 0 |

→ 4th clk $\downarrow$

1   0   1   0

D Q 1 D Q 0 D Q 1 D Q 0

f_{CLK}

CLK ⌐ f_{CLK}

CLK ⎍⌐⎍⌐⎍⌐⎍⌐⎍

Q_A	Q_B	Q_C

→ 0 → 0 → 1

1 → 1 → 0 → 0

2 → 0 → 1 → 0

3   0   0   1

0 0 1
1 0 0
0 1 0
0 0 1

f_{CLK} Q_T

f_{CLK} ⎍⌐⎍⌐⎍⌐⎍⌐⎍

Q_A 1   0   0   0   0   0

Q_B 0   1   0   0   1   0
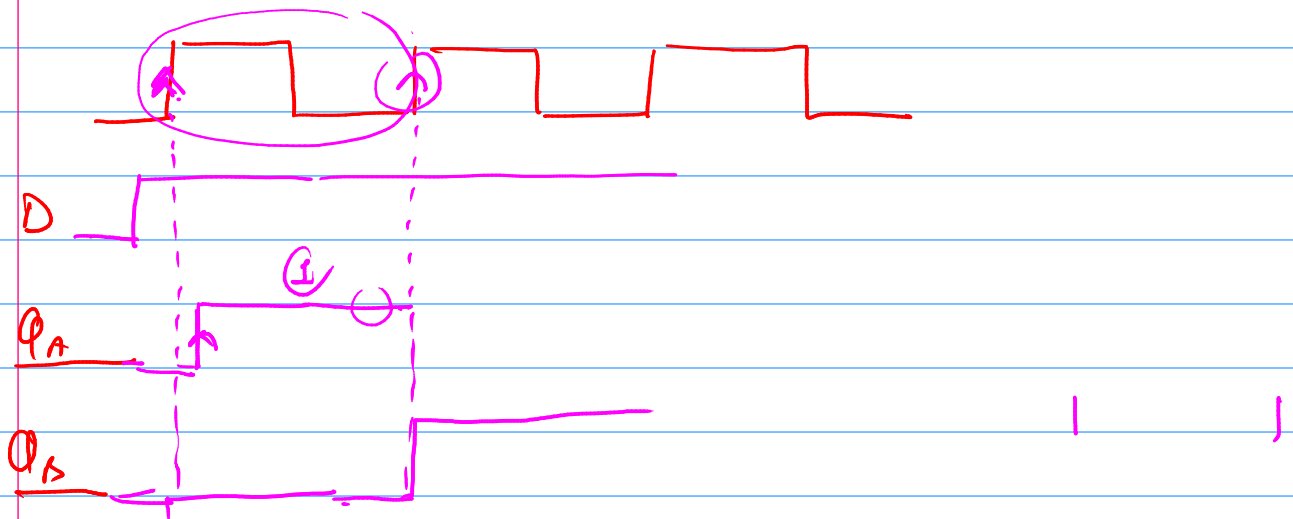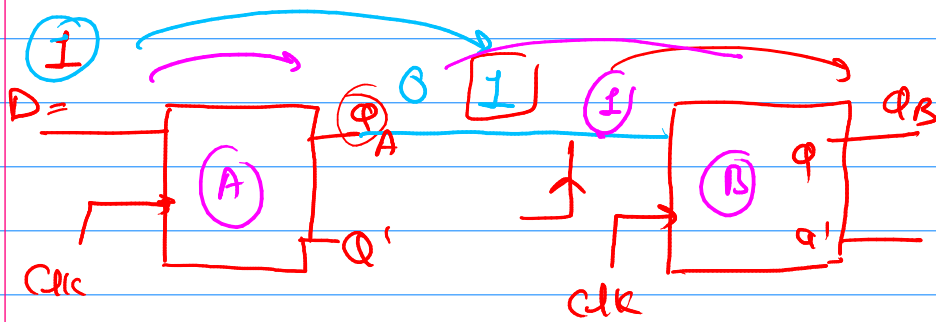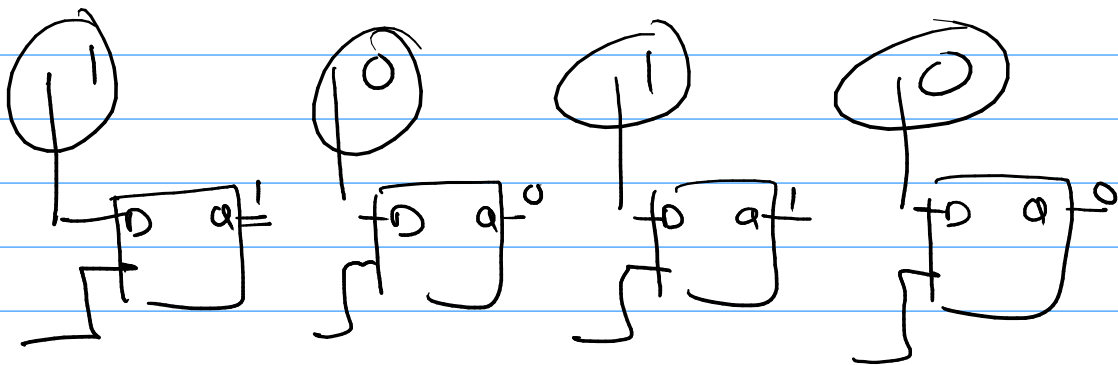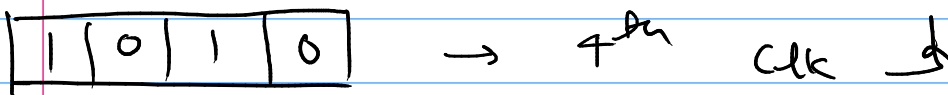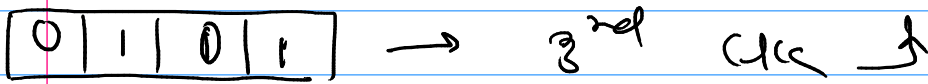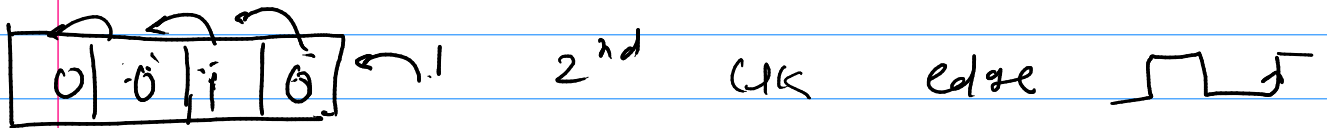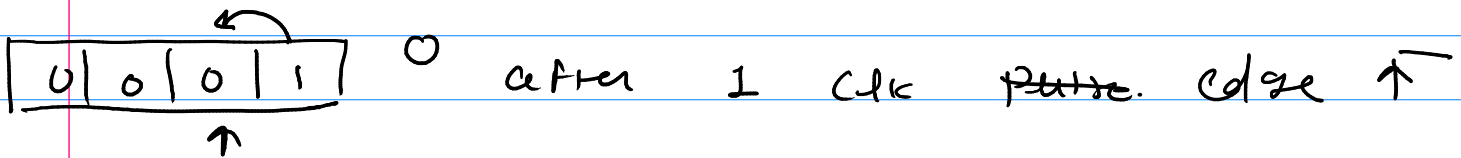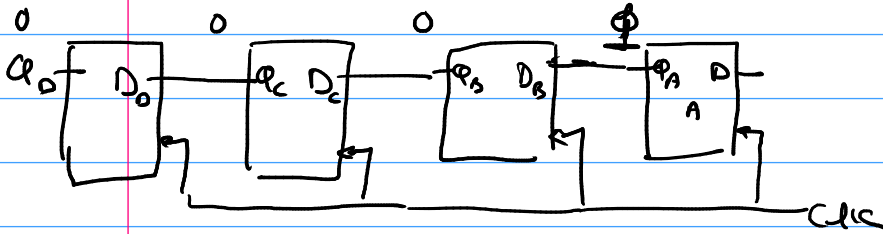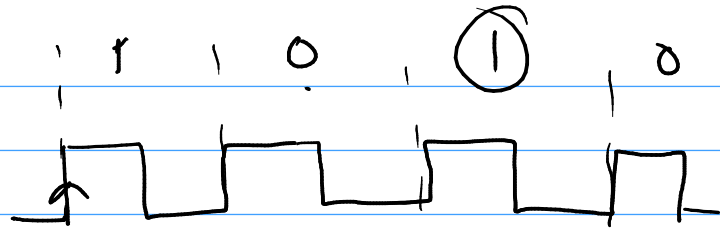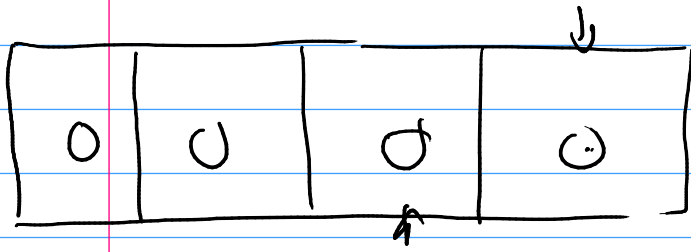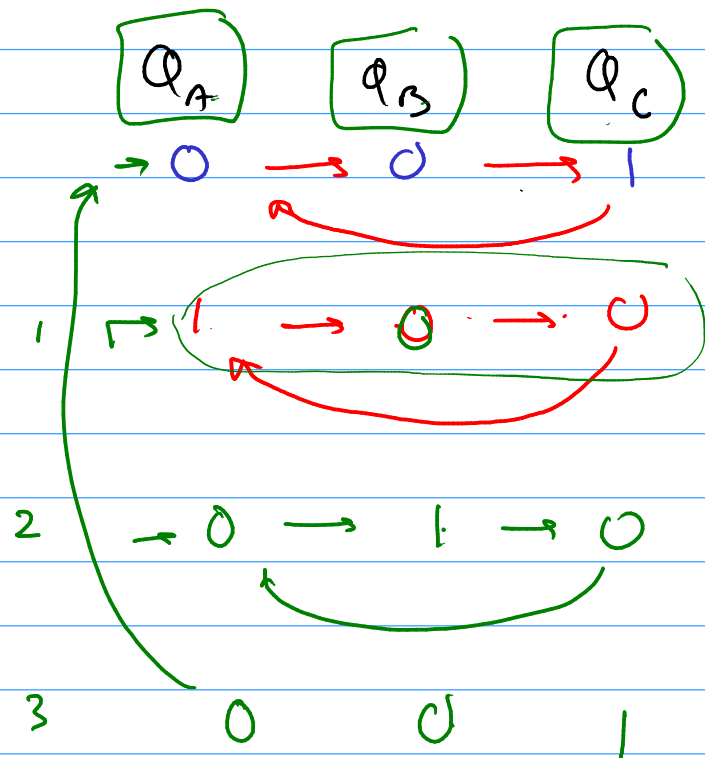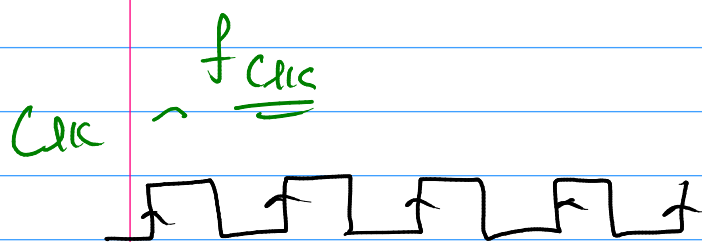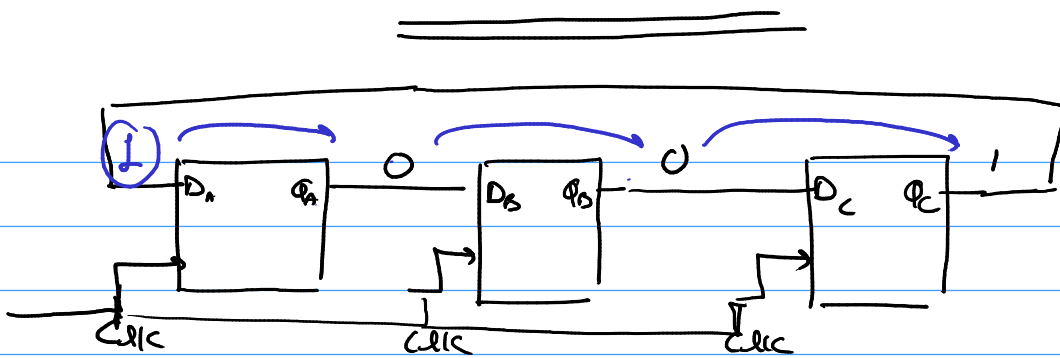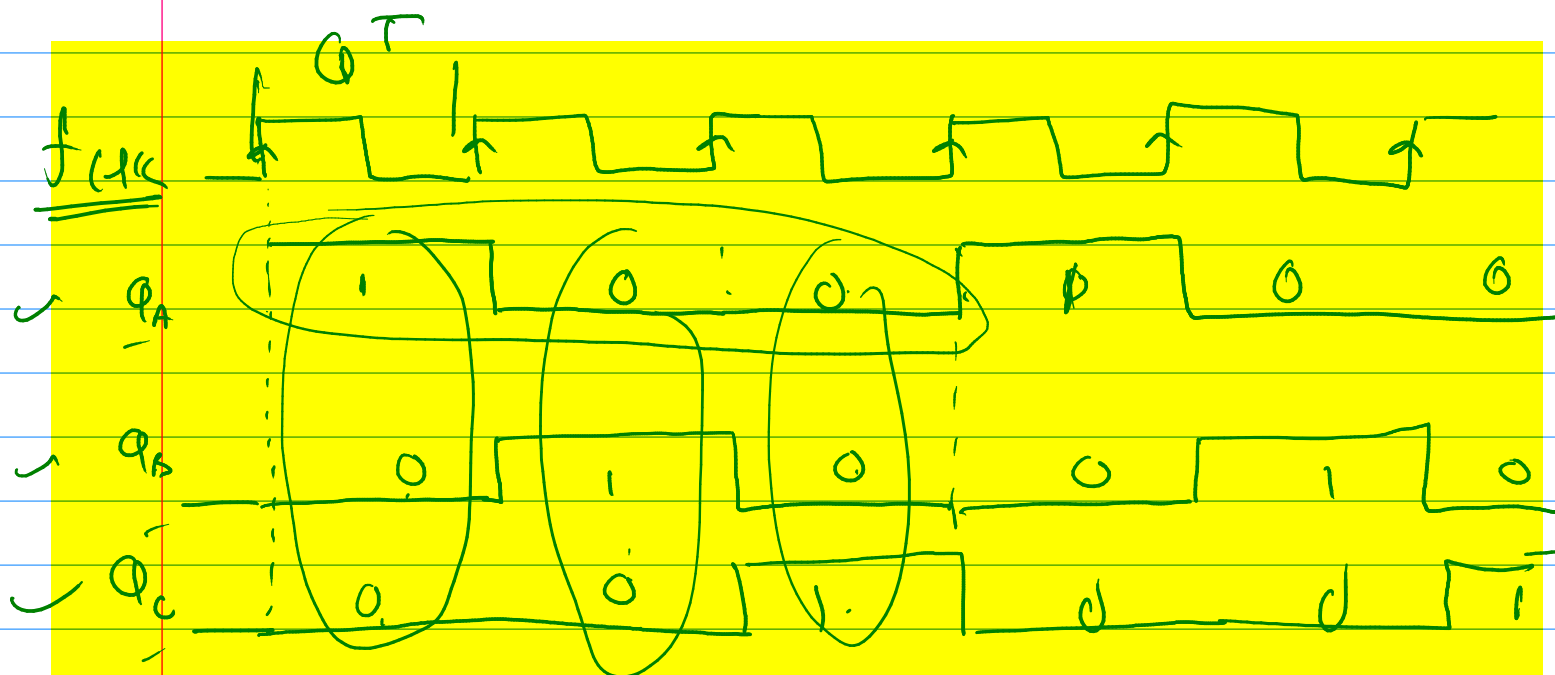
Q_C 0   0   1   0   0   1
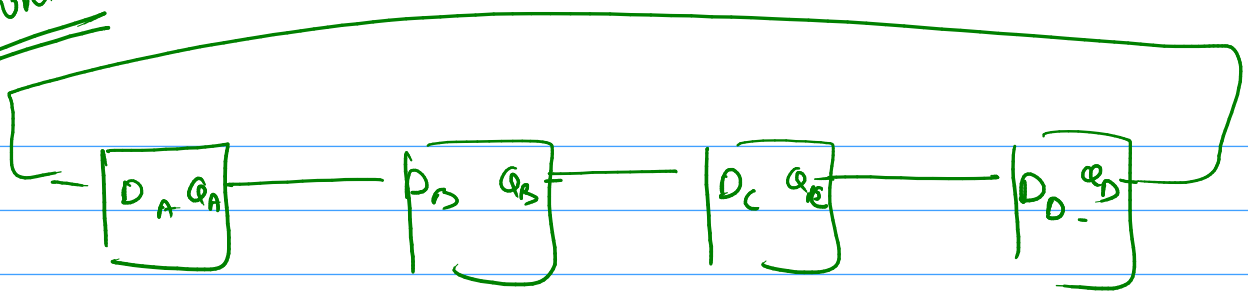
RiNg Counter


```
1 0 0 0
0 1 0 0
0 0 1 0
0 0 0 1
1 0 0 0
```

JohnSon Counter
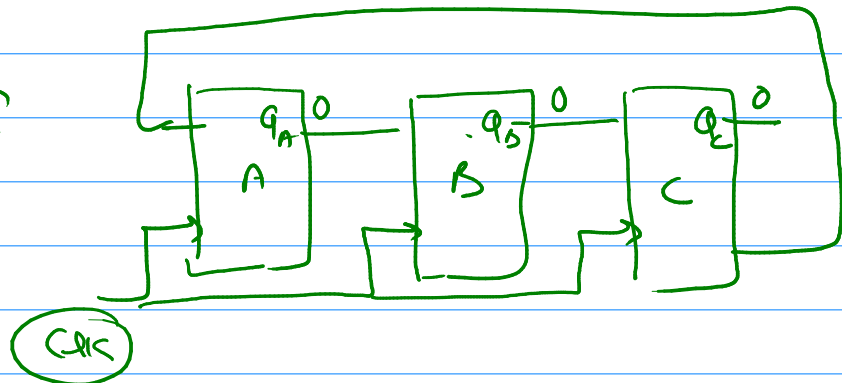
φ_A	Q_B	Q_C
0	0	0
1	0	0
1	1	0
1	1	1
0	1	1
0	0	1
0	0	0

$$f_{Q_\pi} = \frac{f_{CLK}}{6} \Rightarrow$$

50%

Duty cycle

$$n \rightarrow \frac{f_{CLK}}{2n.}$$

φ_A 0 1 1 1 0 0 0 1 1 1 0 0

φ_B 0 0 1 1 1 0 0

φ_C 0 0 0 1 1 1 0

0 0 0 0

1 → 0 → 0 → 0

1 1 0 0

1 1 1 0

1 1 1 1
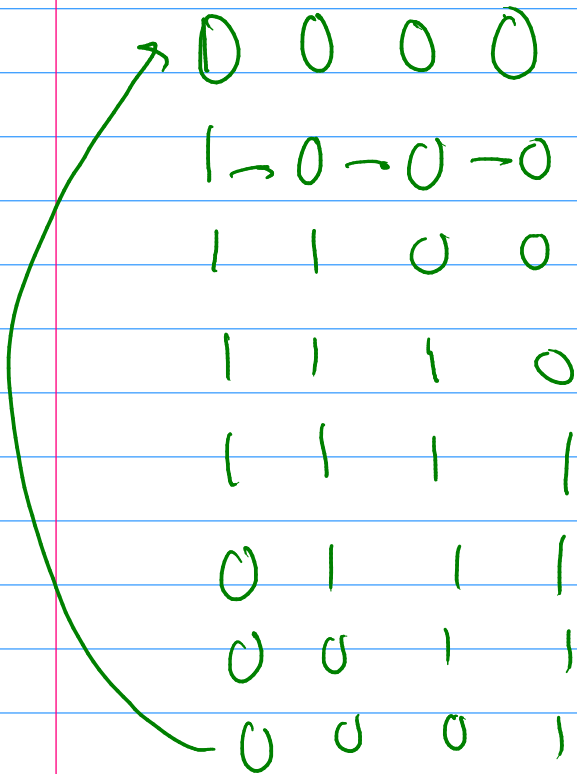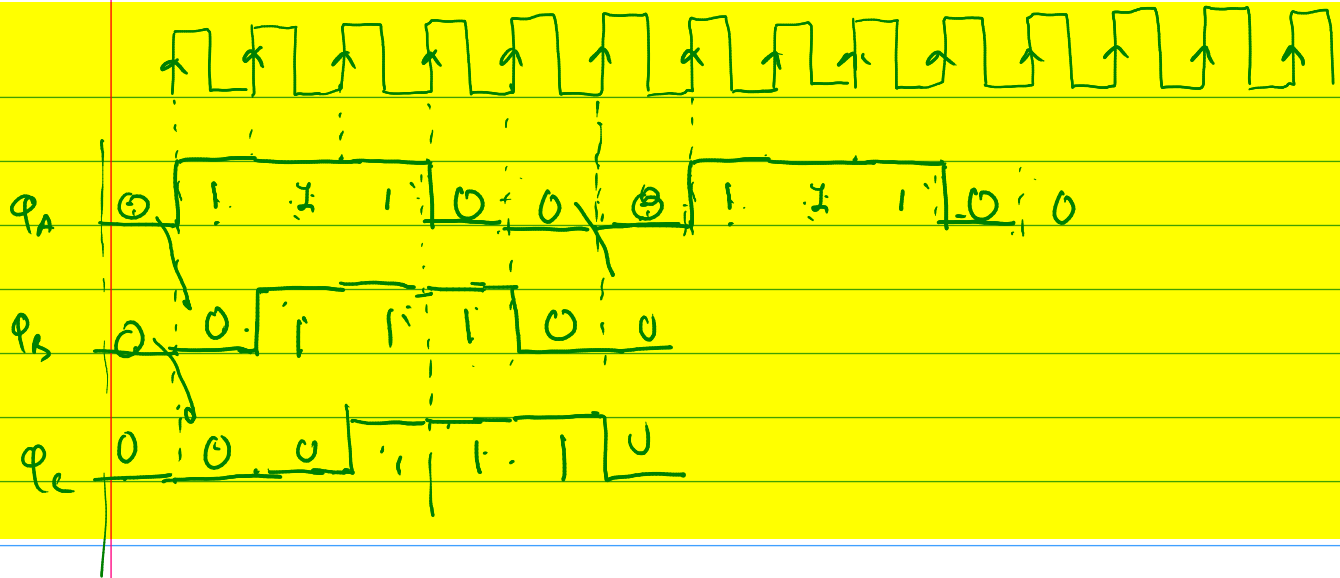
0 1 1 1

0 0 1 1

0 0 0 1

50 %

ASYNCH Blocks

$$001 \curvearrowright 1$$
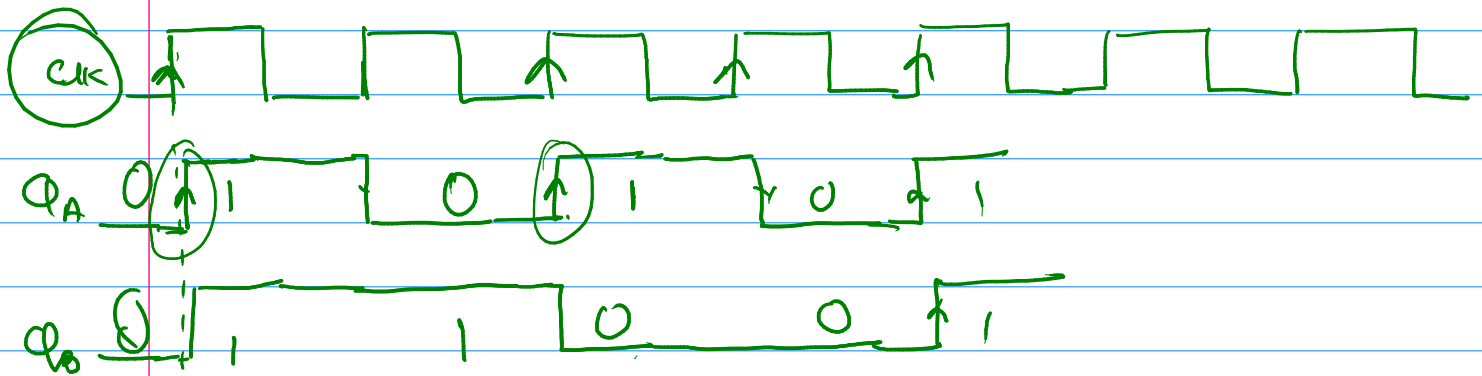$$100 \rightarrow 4$$
$$010 \rightarrow 2$$
$$001 \curvearrowright 1$$

① T ϕ_A ① T_B ② ϕ_B

(A)   Clk (B)

Clk

Clk

ϕ_A 0 ↑ 1   0 ↑ 1   0   1

ϕ_B 0   1   1   0   0   1

ϕ_B	ϕ_A		
1	1	$\rightarrow$	3
1	0	$\rightarrow$	2
0	1	$\rightarrow$	1
0	0	$\rightarrow$	0
1	1	$\rightarrow$	3

1 — T_A — Φ_A — 0   1 — T_B — Φ_B — 0

Φ_A' CLR Φ_B'

CLK

CLK

Q_A 0 | 1. | 0 | ↓ | 0

Q_B 0 | 0 | 1 | 1 | 0
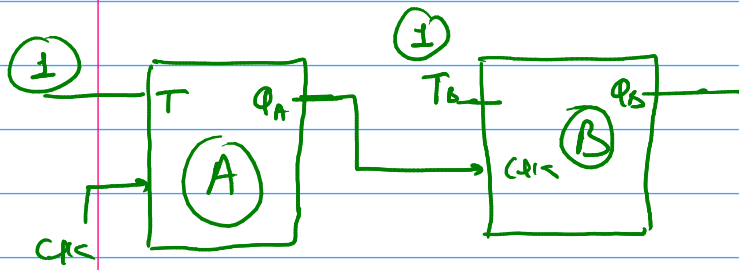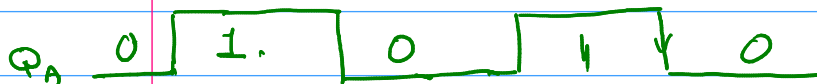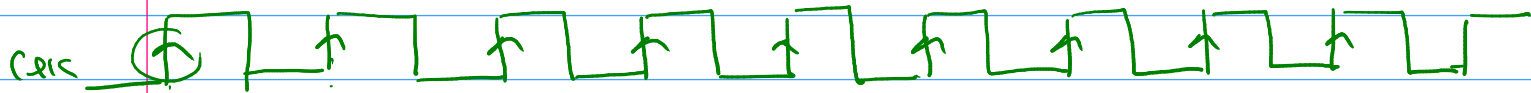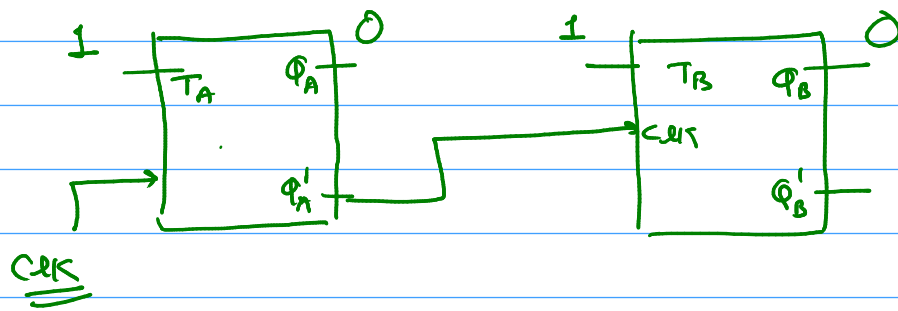
Q_B	Q_A
0	0
0	1
1	0
1	1

Q_C	Q_B	Q_A	
0	0	0	↑
0	0	1	↑
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

$$Q_A = \frac{f_{CLK}}{2}$$

$$Q_B = \frac{f_{CLK}}{4}$$

$$Q_C = \frac{f_{CLK}}{8}$$

0   1   2   3   4   5   6   7

8   9   0

I

$\phi_A' \cdot \phi_B \cdot \phi_C' \cdot \phi_D = \underline{RST}$

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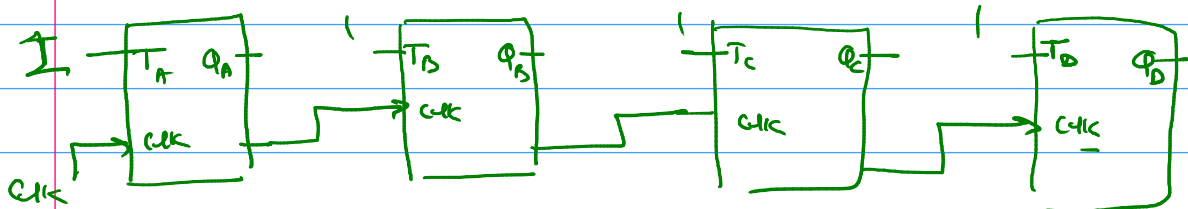
always (Clk , ~~& T~~)

   If (RST == 1)

   then Q = 0

   Else

     if (T == 1)

     then   Q = ∂ Q.

     End;