## Lecture # 8

# LATCH / Flip Flop

A ——⟩ Q

B ——⟩ Q'

A ——⟩ Q
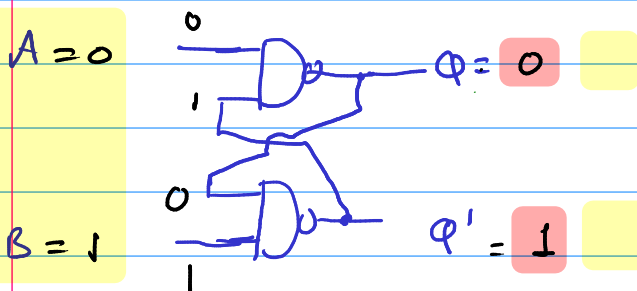
B ——⟩ Q'

Q
Q'
$t = 0$

(A)
(B)
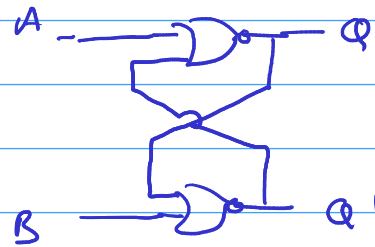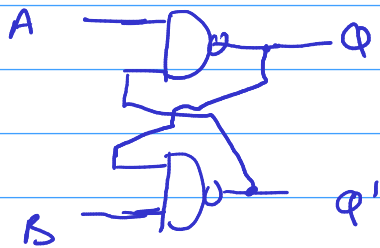
Next State      Present State

N.S.        .S

$Q_{n+1}$ ← $Q_n$

$A = 0$    0 ——⟩ $Q = 0$
      1

    0 ——⟩ $Q' = 1$
$B = 1$    1

| A | B | $Q_n$ | $Q_{n+1}$ | $Q'_{n+1}$ |
|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 1 |
| 0 | 0 | 1 | 1 | 1 |
| 0 | 1 | 0 | 1 | 0 |
| 0 | 1 | 1 | 1 | 0 |

$A = 0$ (N₁)   0 ——⟩ $Q = 0 \quad 1$
   ↓    1

$B = 1$   0→1 ——⟩ $Q' = 1 \quad 0$
    1 (N₂)

$A = 0$   0 ——⟩ $Q = 1 \quad 1$ (N₁)

$B = 1$   1 ——⟩ $Q' = 0 \quad 0$ (N₁)

NAND gate (A, B → Y)

| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

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$A = 0$  
$B = 1$



$Q = \boxed{0}$  
$Q' = \boxed{1}$
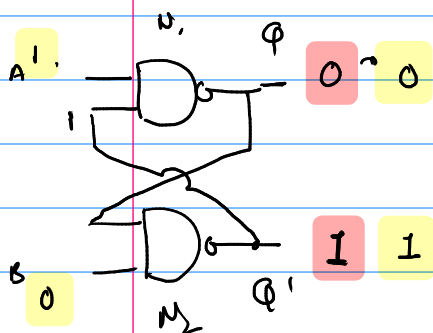
| $A$ | $B$ | $Q_n$ | $Q_{n+1}$ | $Q'_{n+1}$ |
|---|---|---|---|---|
| 0 | 0 | 0 | 1 | i |
| 0 | 0 | (1) | 1 | 1 |
| 0 | 1 | 0 | 1 | 0 |
| 0 | 1 | 1 | 0 |

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$A = 0$  
$B = 1$

  (N₁, N₂)

$Q = \boxed{0}\ 1$  
$Q' = \boxed{1}\ 0$

$A = 0$  
$B = 1$

  (N₁)

$Q = \boxed{1}\ 1$  
$Q' = \boxed{0} \to 0$

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$A\ 1$, $B\ 0$, $N_1$, $N_2$

$Q = \boxed{0} \to 0$  
$Q' = \boxed{1}\ 1$

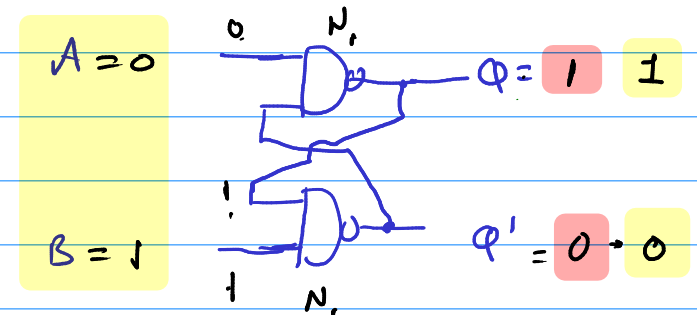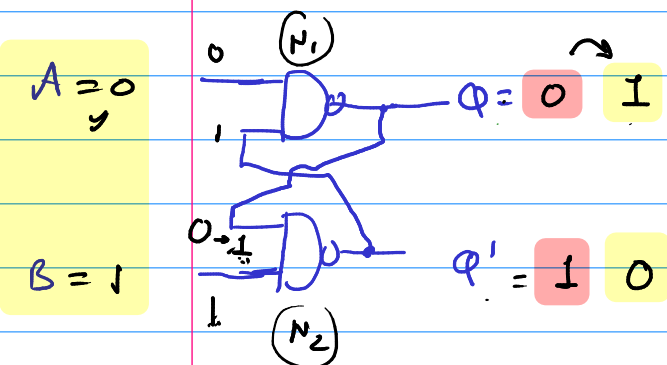| $A$ | $B$ | $Q_n$ | $Q_{n+1}$ | $Q'_{n+1}$ |
|---|---|---|---|---|
| 0 | 0 | 0 | 1 | i |
| 0 | 0 | (1) | 1 | 1 |
| 0 | 1 | 0 | 1 | 0 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 | 1 |
| 1 | 0 | 1 | 0 | 1 |



$A\ 1$, $B\ 0$, $N_1$, $N_2$

$Q = \boxed{1} \to 0$  
$Q' = \boxed{0} \to 1$

A **1**

Q

N₁

**0** **0**

1

0

**1** **1**

Q'

B **1**

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① Problem

write

0 = 1

② write

∴ 0

③ No CHANGE ?

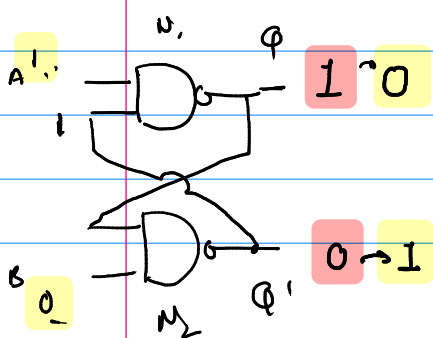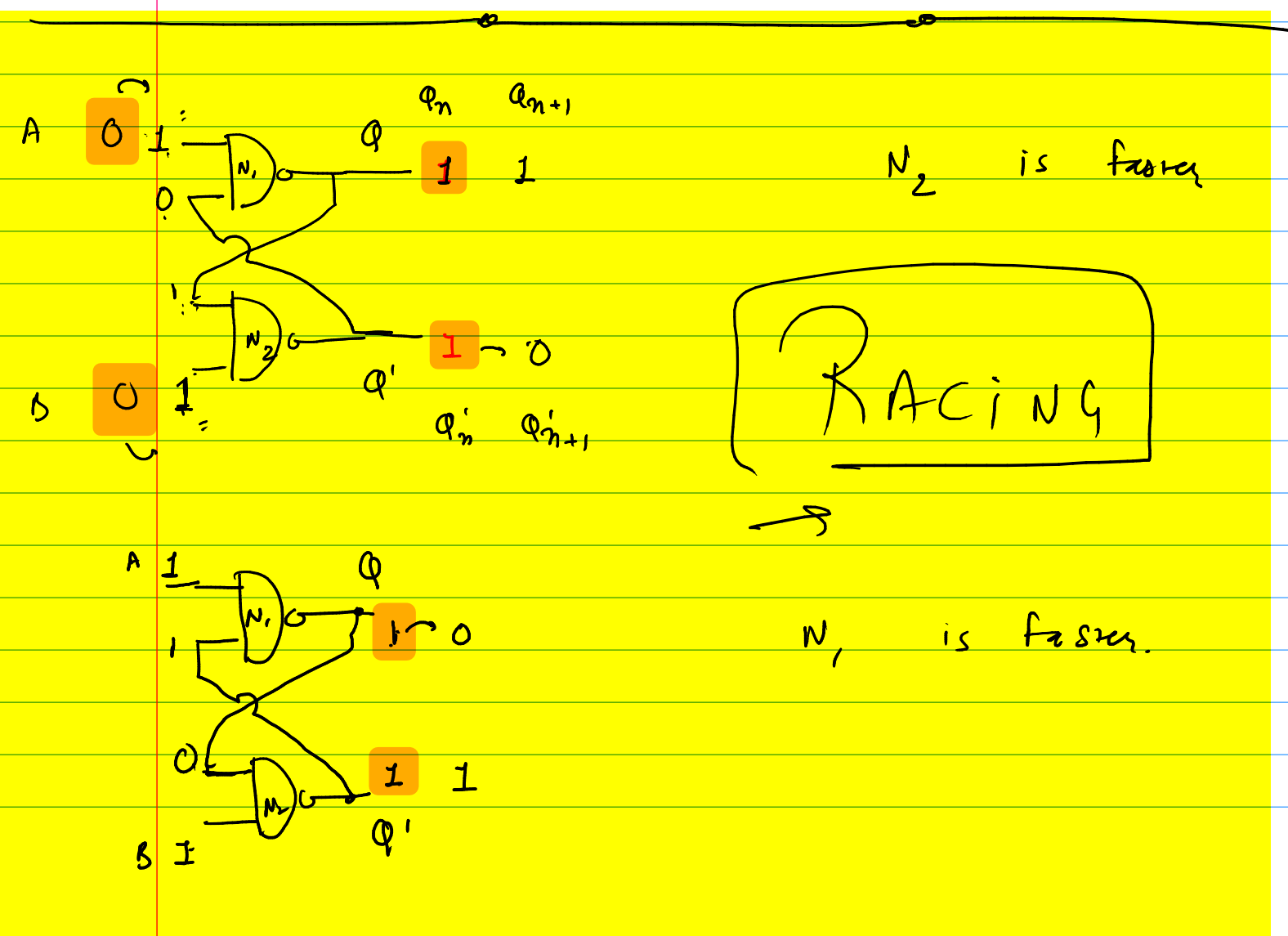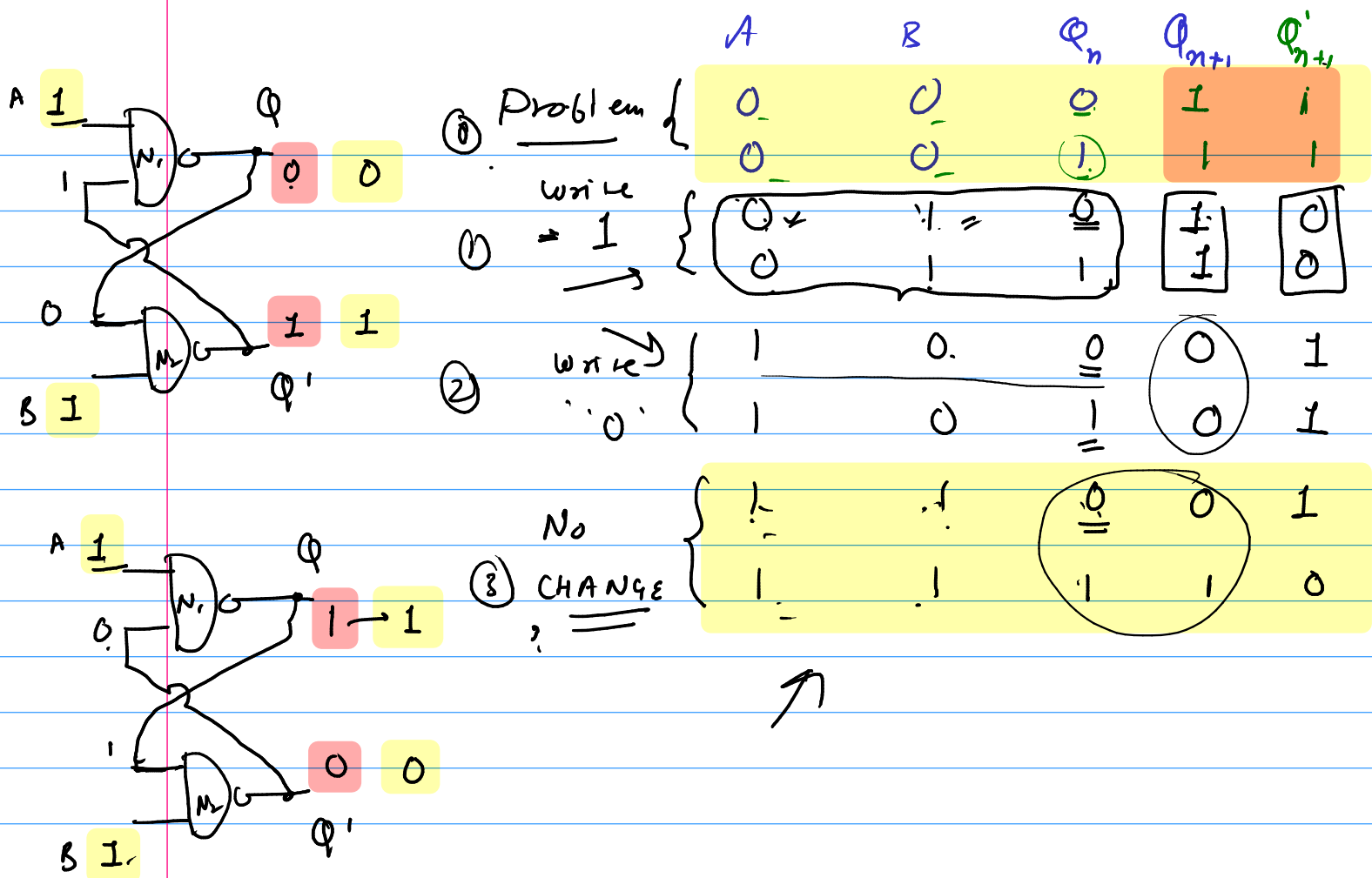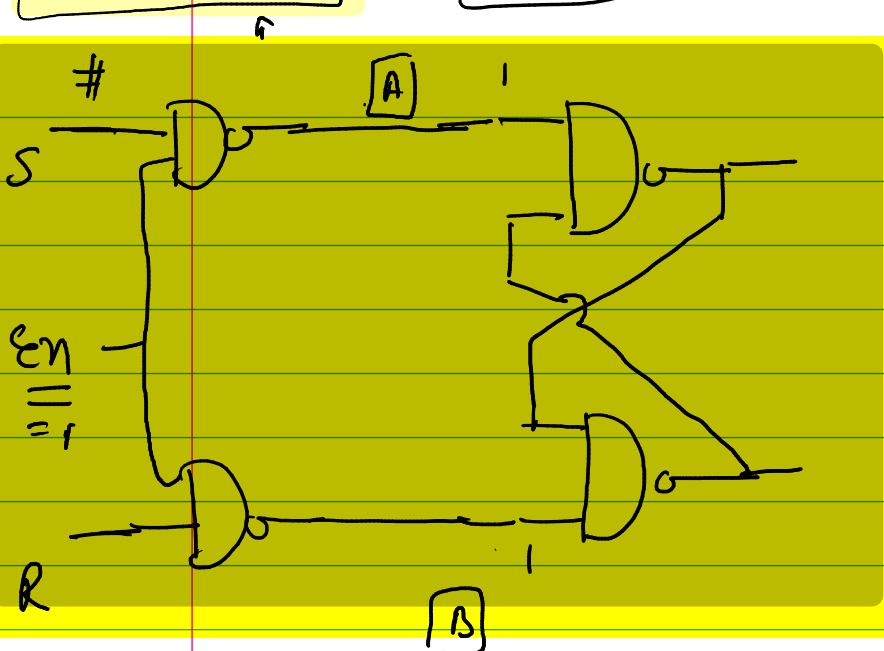| A | B | $Q_n$ | $Q_{n+1}$ | $Q'_{n+1}$ |
|---|---|---|---|---|
| 0 | 0 | 0 | **1** | 1 |
| 0 | 0 | 1 | 1 | 1 |
| 0 | 1 | 0 | 1 | 0 |
| 0 | 1 | 1 | 1 | |
| 1 | 0 | 0 | 0 | 1 |
| 1 | 0 | 1 | 0 | 1 |
| 1 | 1 | 0 | 0 | 1 |
| 1 | 1 | 1 | 1 | 0 |

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A **1**

Q

N₁

**1** → 1

0

1

**0** → 0

Q'

B **1**

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A **0** 1

0

N₁

Q

$Q_n$ $Q_{n+1}$

**1** 1

N₂

**1** → 0

Q'

B **0** 1

$Q'_n$ $Q'_{n+1}$

$N_2$ is faster

RACING

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A **1**

Q

N₁

1

**1** → 0

0

N₂

**1** 1

Q'

B 1

$N_1$ is faster.
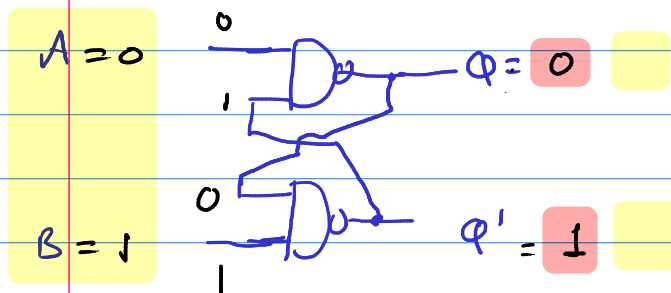
# SR - LATCH

## En = 0



| A | B | $Q_{n+1}$ |
|---|---|-----------|
| 1 | 1 | $Q_n$ |

No Change

when En = 1
A = S' , B = R'

| S | R | En | A | B | $Q_{n+1}$ |
|---|---|----|----|----|-----------|
| X | X | 0 | 1 | 1 | $Q_n$ |
| 0 | 0 | 1 | 1 | 1 | $Q_n$ |
| 0 | 1 | 1 | 1 | 0 | 0 |
| 1 | 0 | 1 | 0 | 1 | 1 |
| 1 | 1 | 1 | 0 | 0 | NOT VALID |
| — | — | | | | |

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## # SUMMARY

En = 1

① S = 0    R = 1 ⟿ RESET the O/P → '0'
② S = 1    R = 0 → set the O/P → '1'
③ S = 0    R = 0 → NO CHANGE (storing)
   En = 0
   $Q_{n+1} = Q_n$

# Problems:

$S = 1$ , $R = 1$ $\longrightarrow$ $Q_{n+1} = Q'_{n+1} =$

$A = 0$ , $B = 0$

$\mathcal{1}$

$S = 1 \rightarrow 0$ $\longrightarrow$ $Q_{n+1} =$ either '0'

$R = 1 \rightarrow 0$ or '1'

## RACING

$Q_{n+1} = f\left(Q_n, \varepsilon_n, S, R\right)$

# D - LATCH → Level Sensitive
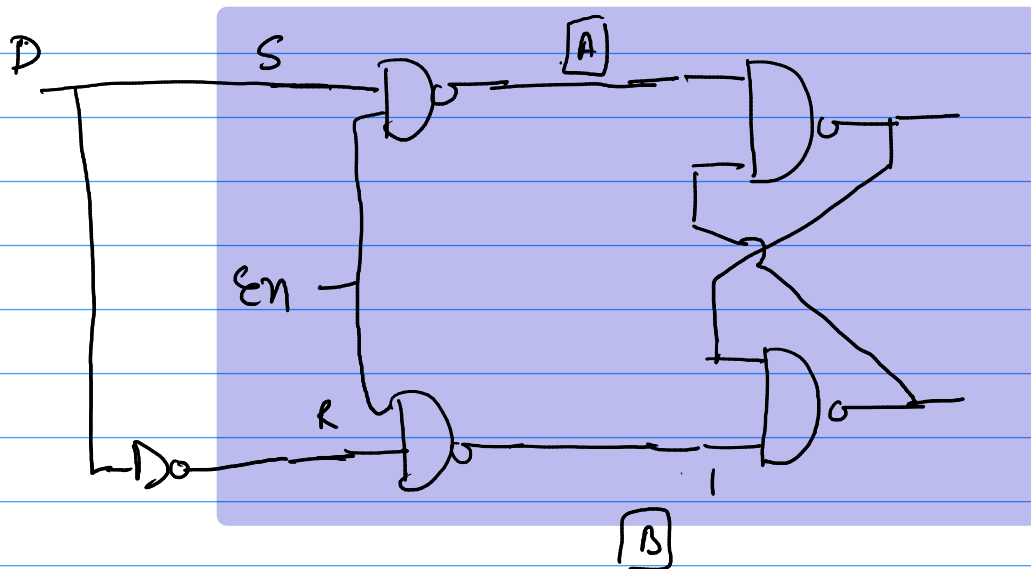


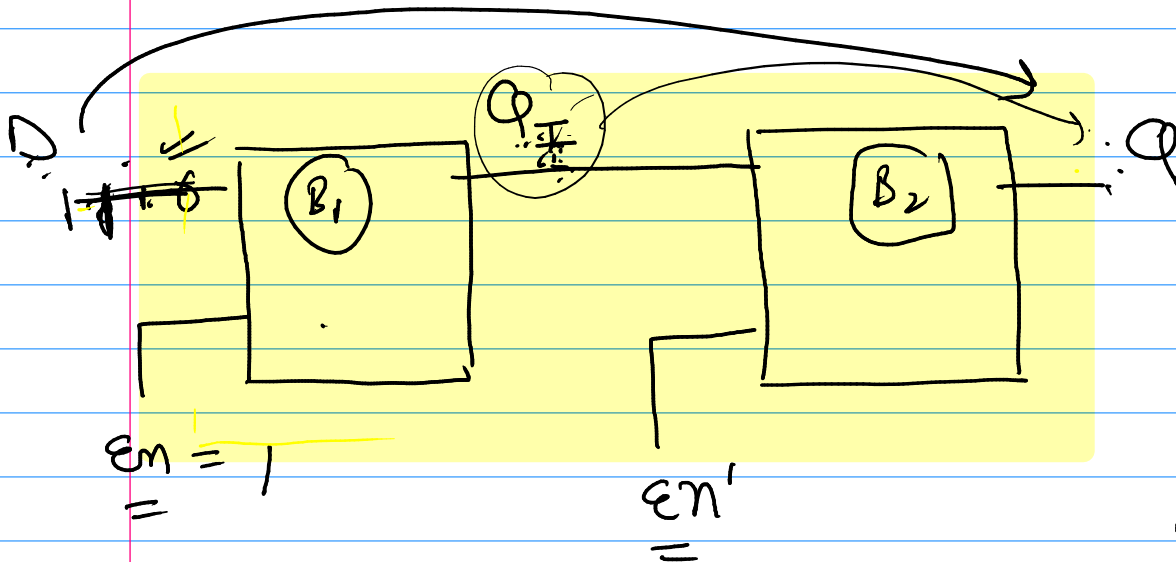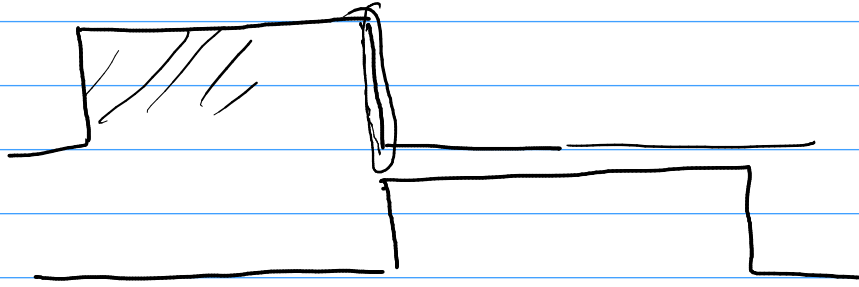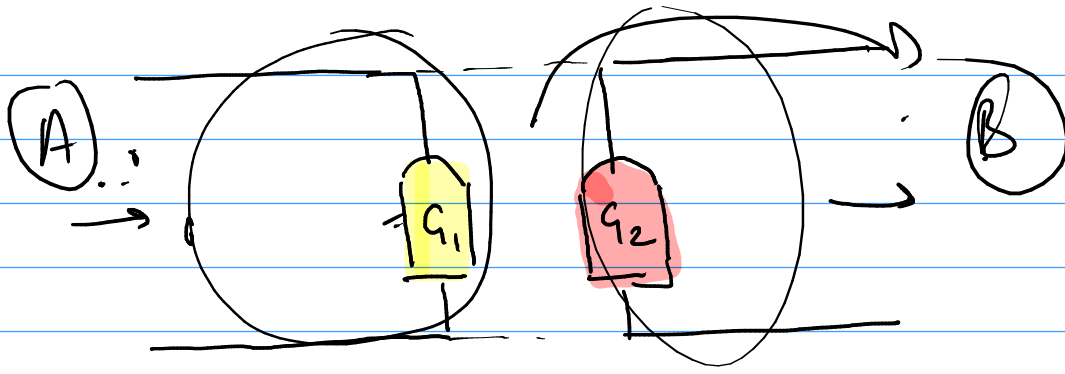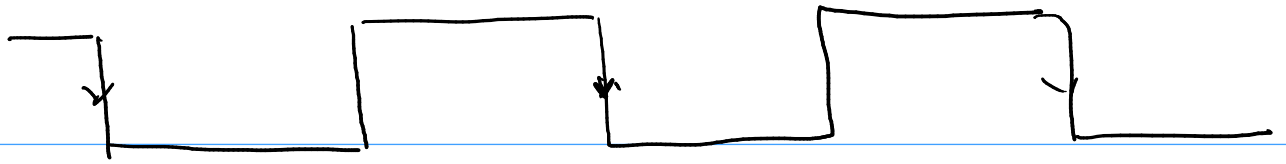| En | D | S | R | A | B | $Q_{n+1}$ |
|----|---|---|---|---|---|-----------|
| 0 | X | X | X | 1 | 1 | $Q_n$ (No Change) |
| 1 | 0 | 0 | 1 | | | $\boxed{0}$ |
| 1 | 1 | 1 | 0 | | | 1 |



Level = 1

En

D     1

$Q_{n+1}$

$\boxed{Q_n = 0}$

$$Q_{n+1} = f(Q_n, D, En) = En \cdot D + En' \cdot Q_n$$

#



(A)

(B)

$q_1$

$q_2$



D

$\phi$

$B_1$

$B_2$

$\phi$

$En = 1$

$En'$

$En = 1$

Yellow $En$

RES

$En'$
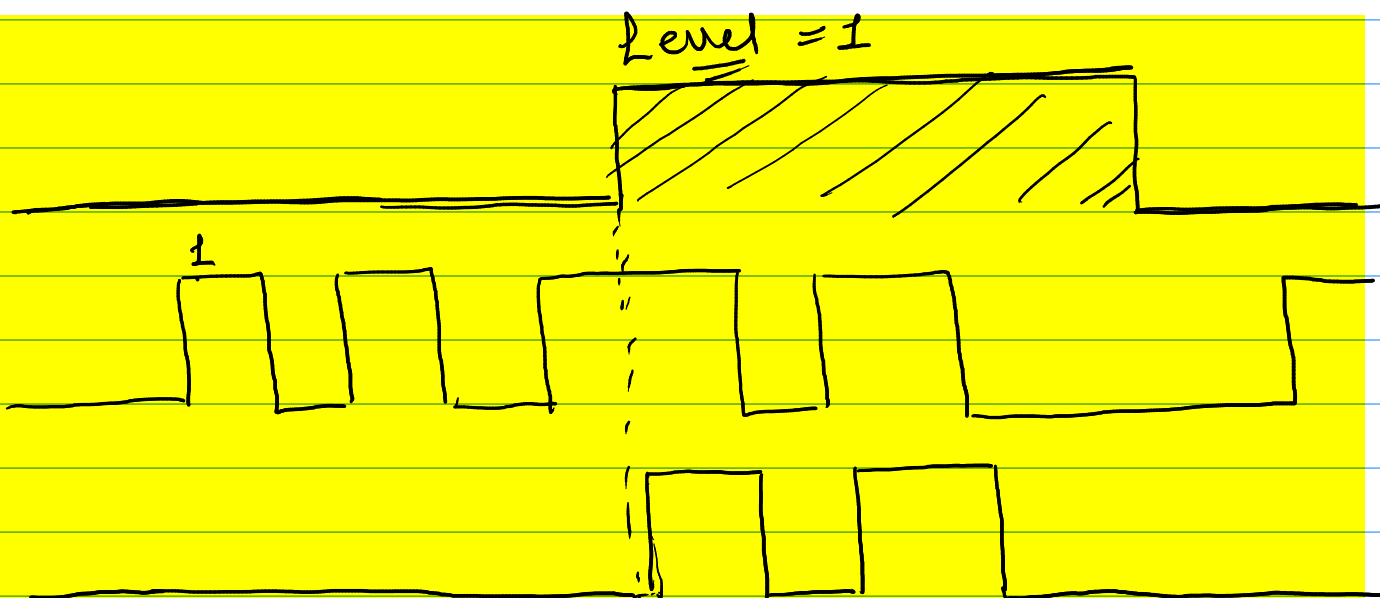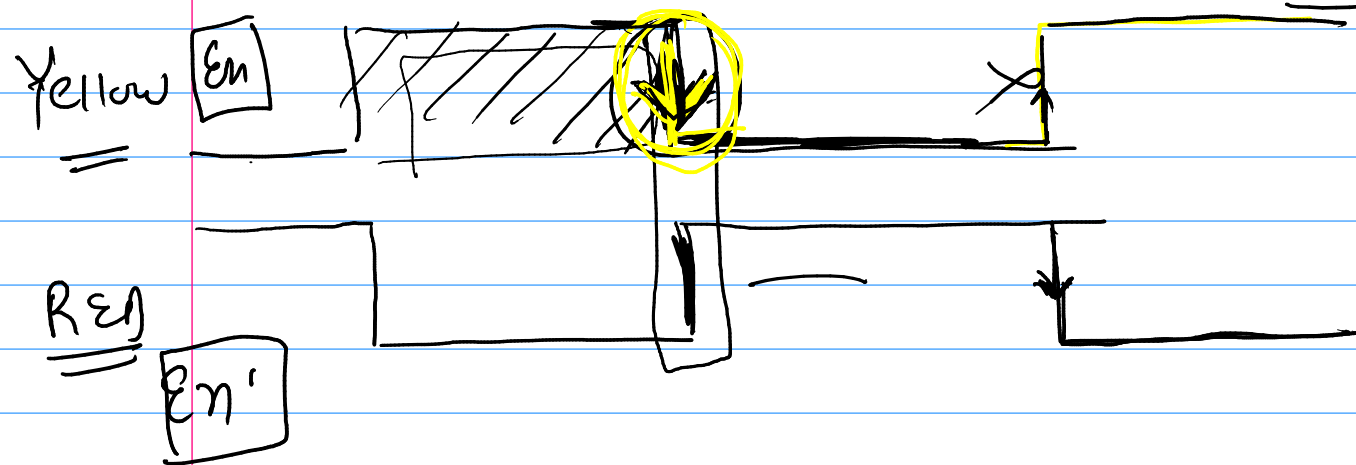
Flip Flop's

always @ (posedge clk)

(-ve) ==edge triggered flip flop==



D

Q

En

En'

==(+ve) edge triggered →==

MASTER

↓ SLAVE

D ⎯⎯ | i/p   o/p | ⎯⎯ | i/p   o/p | ⎯ Q

En'

En