Chap 6 Registers and Counters

Ripple Counters

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Counter

- Every time input pulse is applied, the state of the register is increased sequentially ➔ Counter
- A counter that follows the binary number sequence is called a binary counter.
- An n-bit binary counter consists of n flip-flops and can count in binary from 0 through 2^n-1.

Two categories:
Ripple counter & Synchronous counter

- In a ripple counter, FF output transition serves as a source for triggering other flip-flops.
  ➔ The clock input (C) of some or all flip-flops are triggered by the transition that occurs in other flip-flop outputs.
- In a synchronous counter, C of all flip-flops receive the common clock.

Designing Binary Ripple Counter

- Begin with the following table

Table 6.4
Binary Count Sequence

A_3	A_2	A_1	A_0
0	0	0	0
0	0	0	1
0	0	1	0
0	0	1	1
0	1	0	0
0	1	0	1
0	1	1	0
0	1	1	1
1	0	0	0

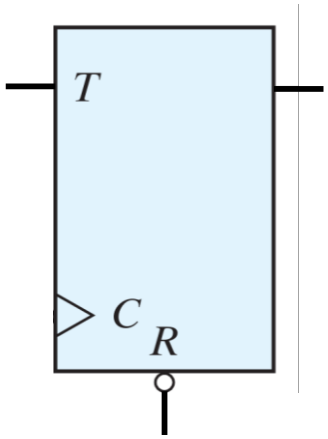
You can observe that
the frequency of changing (or toggling)
becomes half with a larger digit!

➔ Every edge of input, A_0 should be changed

➔ What kind of FF would be proper?

Let's Use T-FF

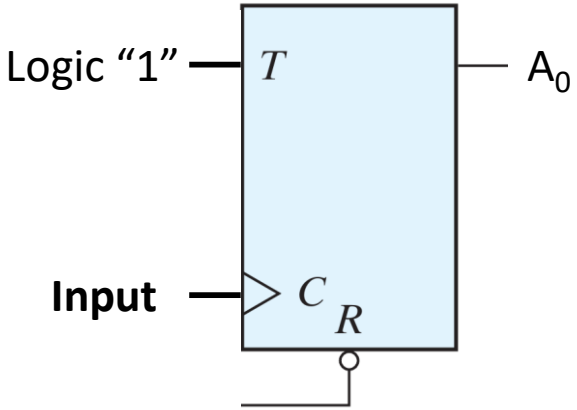
- Revisit T-FF. What is the operation ?



T Flip-Flop

T	Q(t + 1)	
0	$Q(t)$	No change
1	$Q'(t)$	Complement

- So we can start from like this, for making A_0:



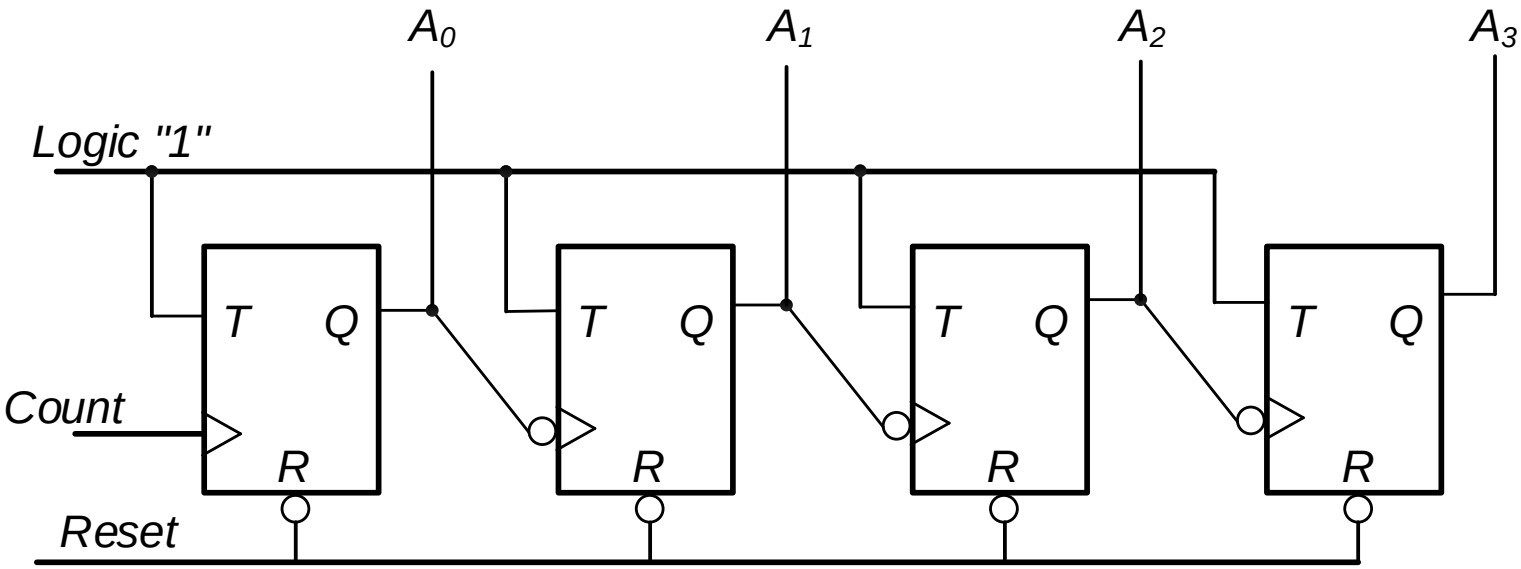
With initially reset, can you draw the waveform of A_0 for the pulsed input (or we name it "Count")?

Let’s Develop to Higher Digit

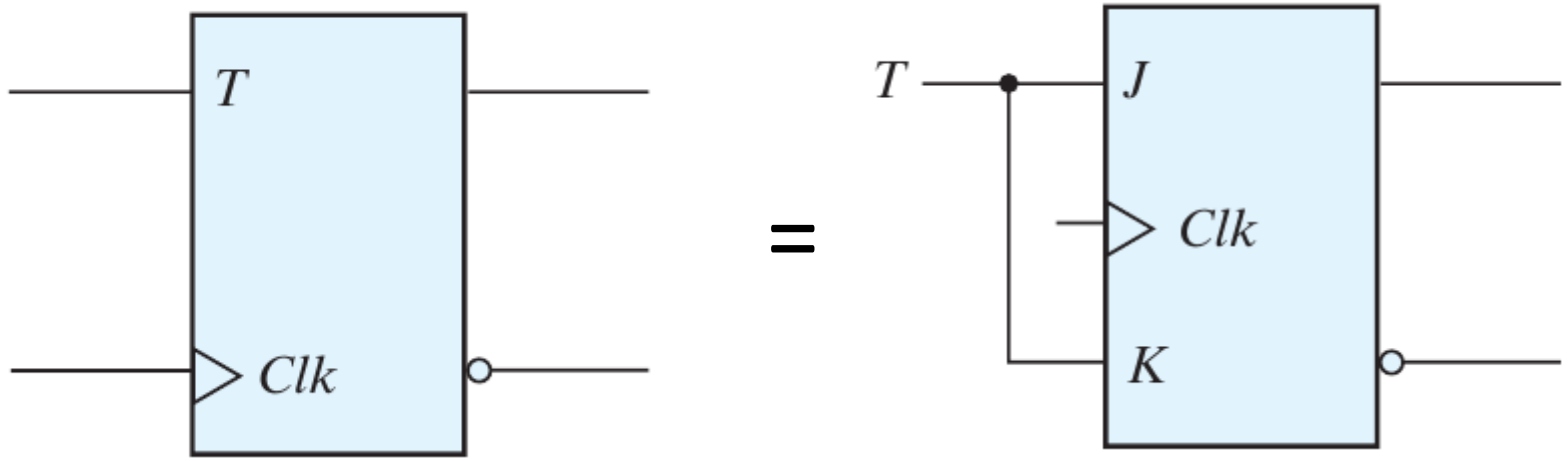
- We can extend the idea to reflect its half toggling frequency with one bit higher digit.

- To start A1 from “0,” we should do..

T-FF based Binary Ripple Counter



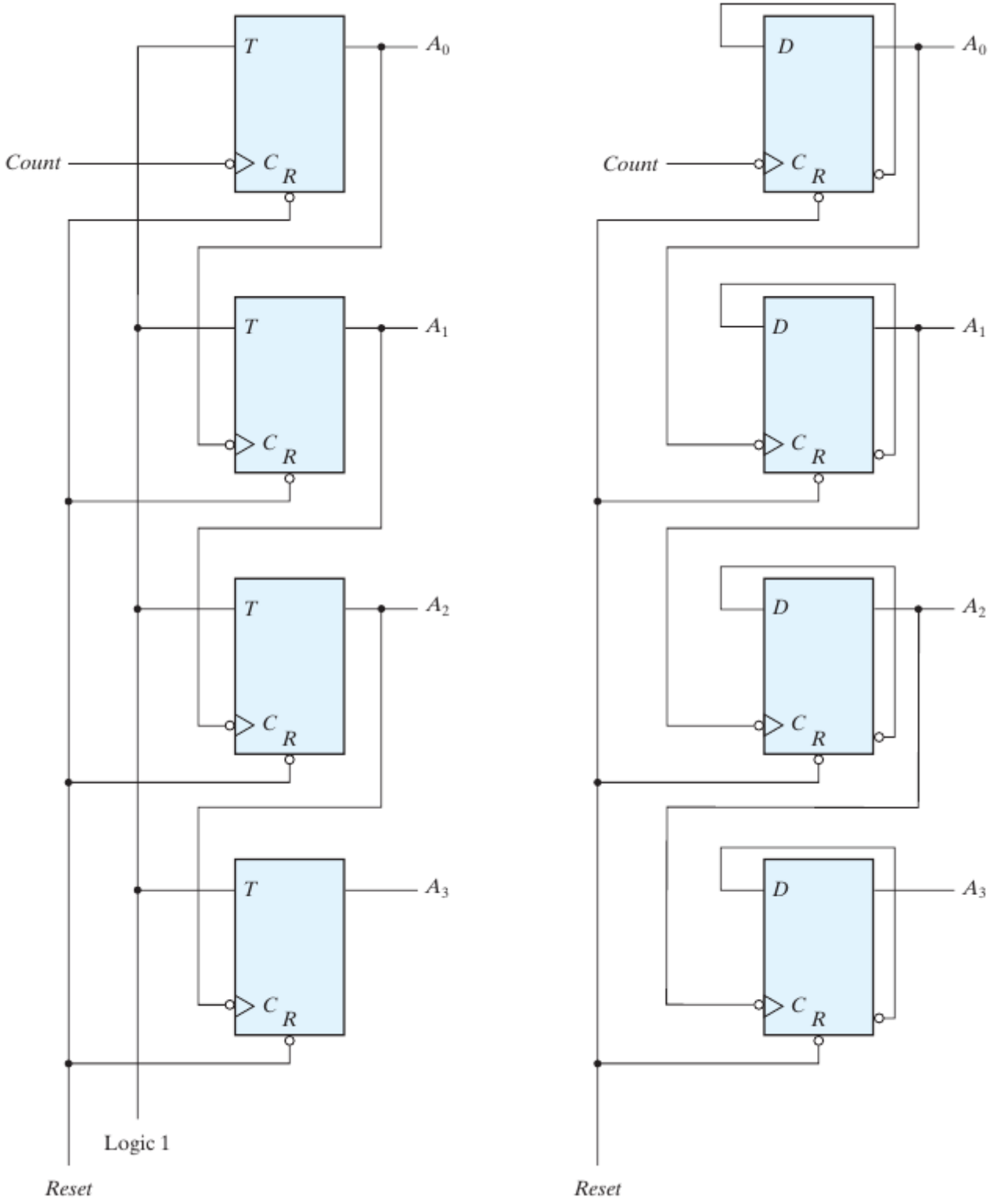
Often, J-K FF with Tied Input is Used



Can You Utilize D-FFs?

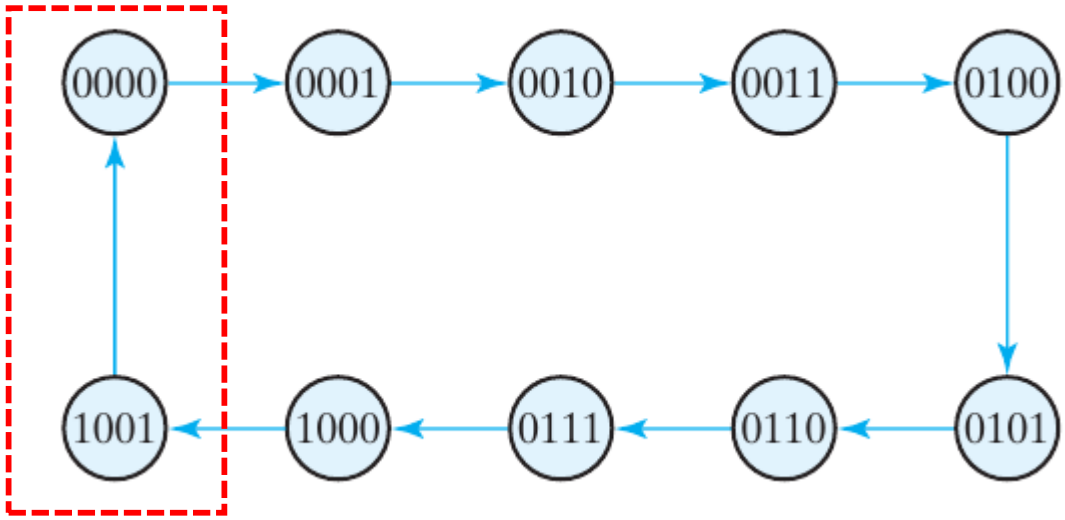
- How can we make D-FF toggle every clock edge?
- Did you remember how we hold the data with D-FF?

- Then you can also make it toggle for every clock cycle
  ➔ Then D-FF becomes equivalent to T-FF with T=1.


T
C
R
A_0
A_1
A_2
A_3
Count
Logic 1
Reset
D
C
R
A_0
A_1
A_2
A_3
Count
Reset

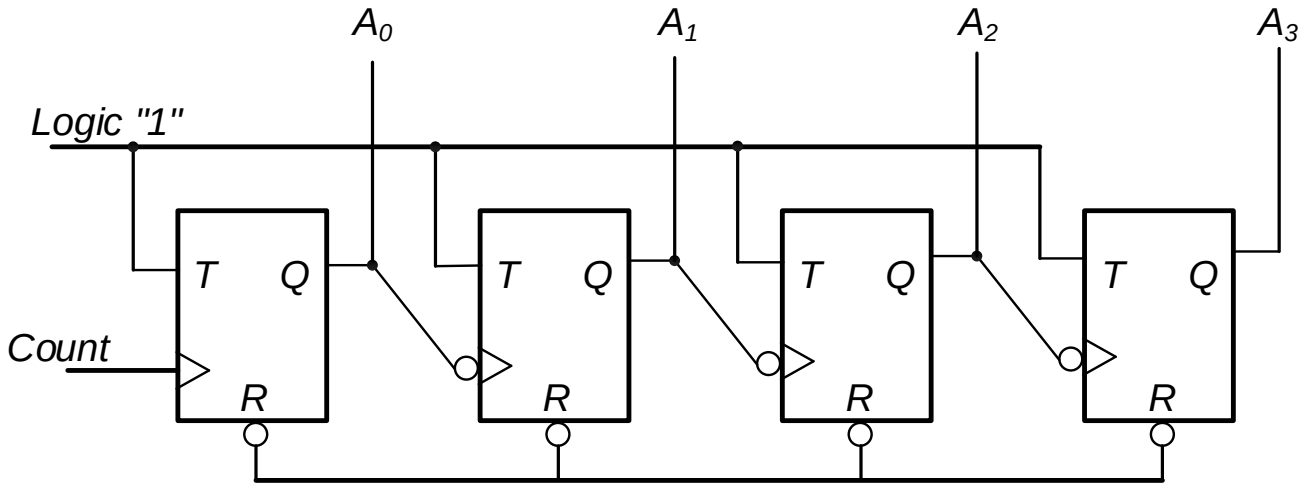
BCD Ripple Counter

- A decimal counter follows a sequence of 10 states and **returns to 0 after the count of 9**.
- It is same with binary counter otherwise.
- How can we realize this? Returning to 0000 after 1001



Preventing of Appearing 1010

- Instead of 1001 → 1010, 1010 → 0000



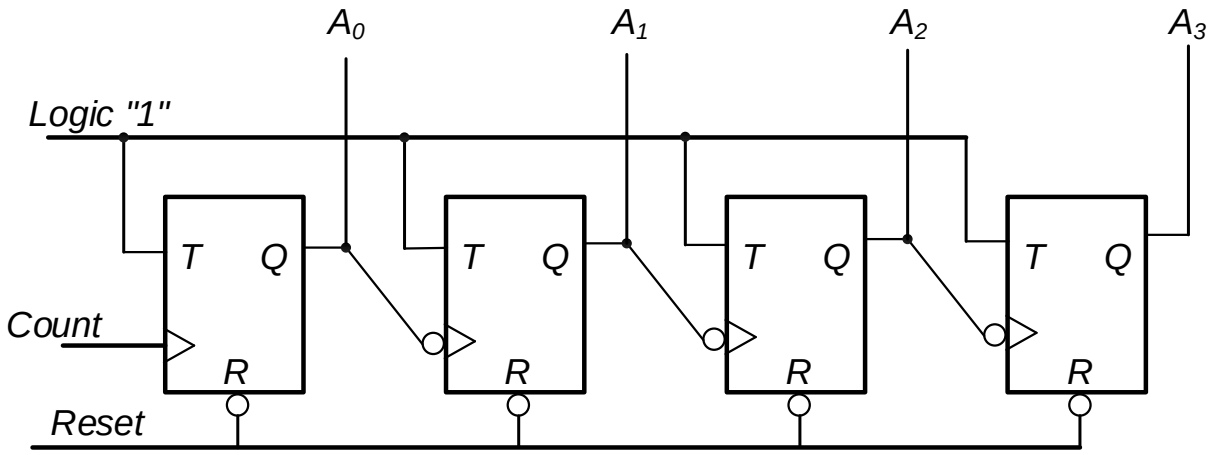
How about This? Bit by Bit Anlaysis

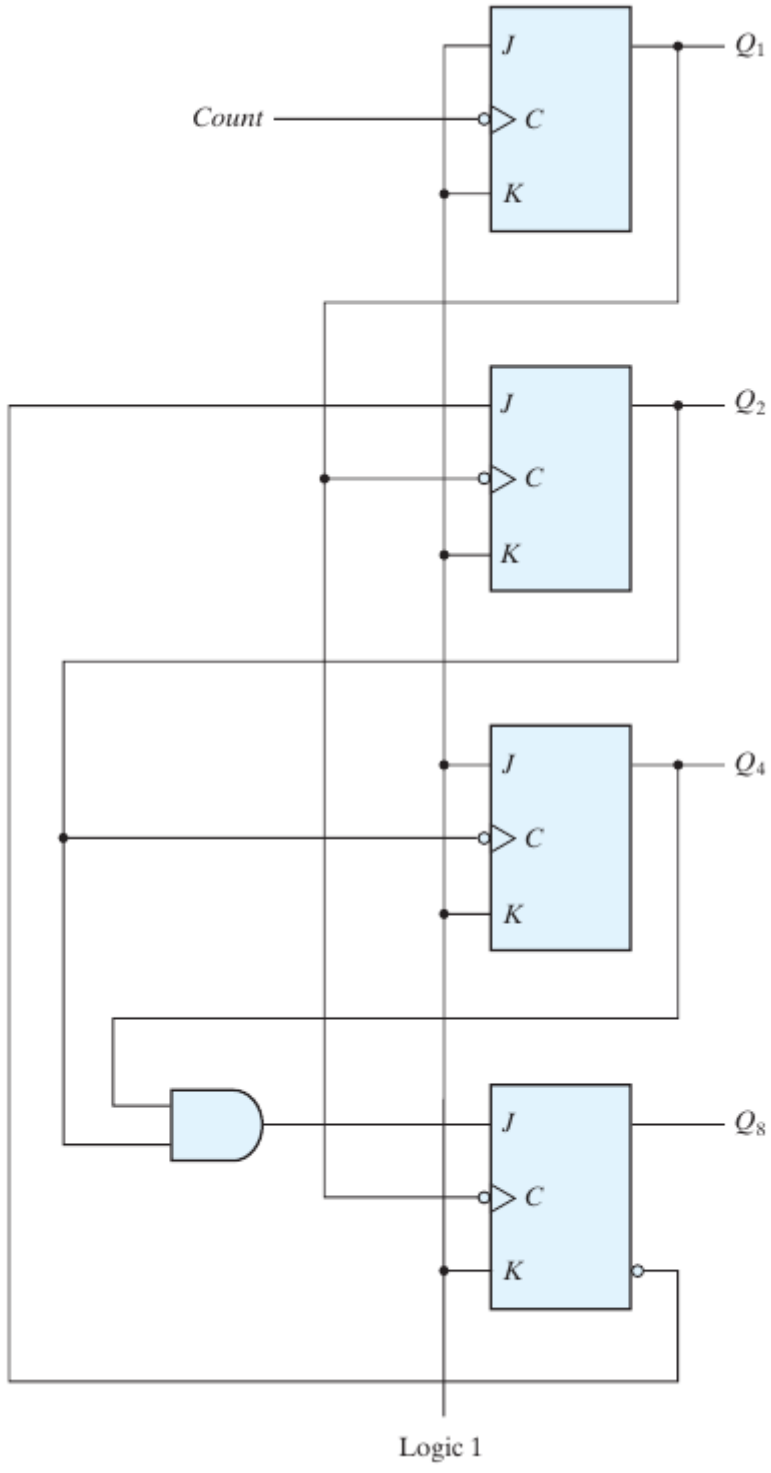
- A_0 toggles every sequence
  ➔ same as binary ripple
- A_1 toggles when A_0: 1 → 0 **except A_3 = 1**.
  - **When A_3 =1, A_1 is fixed to 0**
    ➔ Toggling is stopped but A_1 is reset
    ➔ For some condition toggle, but for some condition A1 can make fixed output
    ➔ We can use JK FF instead of T-FF
- A_2 toggles when A_1: 1 → 0
  ➔ same as binary ripple
- A_3 **toggles to 1 only when $A_2A_1A_0$: 111 → 000**
  - Otherwise, fixed to 0

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0	1	0	0
0	1	0	1
0	1	1	0
0	1	1	1
1	0	0	0
1	0	0	1
0	0	0	0
0	0	0	1
0	0	1	0
0	0	1	1
		....	

Where Should be Modified?




J
C
K
Count
Q_1
Q_2
Q_4
Q_8
Logic 1