Modulo-N Counter

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Mod-N counter

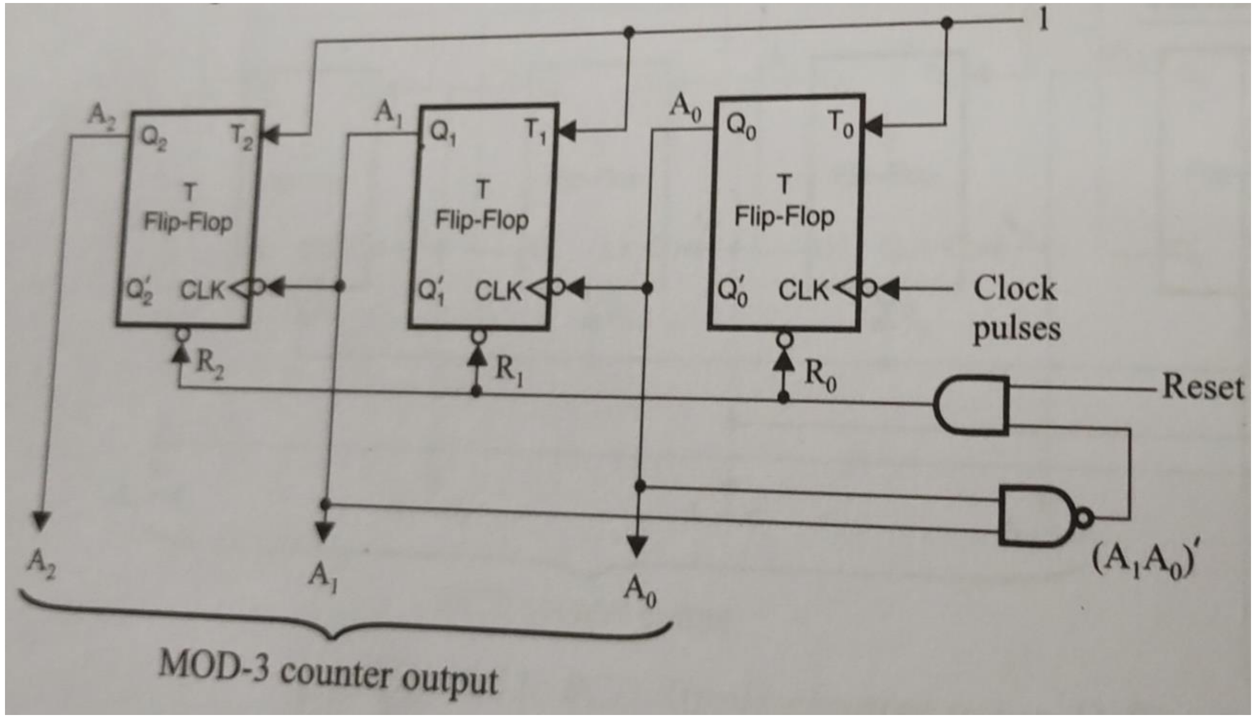
Modulus *Counters*, or simply *MOD counters*, are defined by the number of states they will cycle through before returning to their original value.

A decade *counter* is called as *mod* -10 or divide by 10 *counter*. It counts from 0 to 9 and again reset to 0

Mod-3 counter using 3 flip-flops

A 3-bit binary counter will work as MOD-3 counter if A1 and A0 are NANDed and output of NAND gate is ANDed with reset.

Now, the counter will reset in every third clock pulse.



Clock pulse	A2	A1	A0
1	0	0	0
2	0	0	1
3	0	1	0

We have discussed ring/Johnson/binary/BCD counters.

Lets see them as modulo-N counters and find what is N?

BCD counter (synchronous)

This state table for BCD counter shows that it outputs 1 (y) after 10 clock cycles.

State Table for BCD Counter

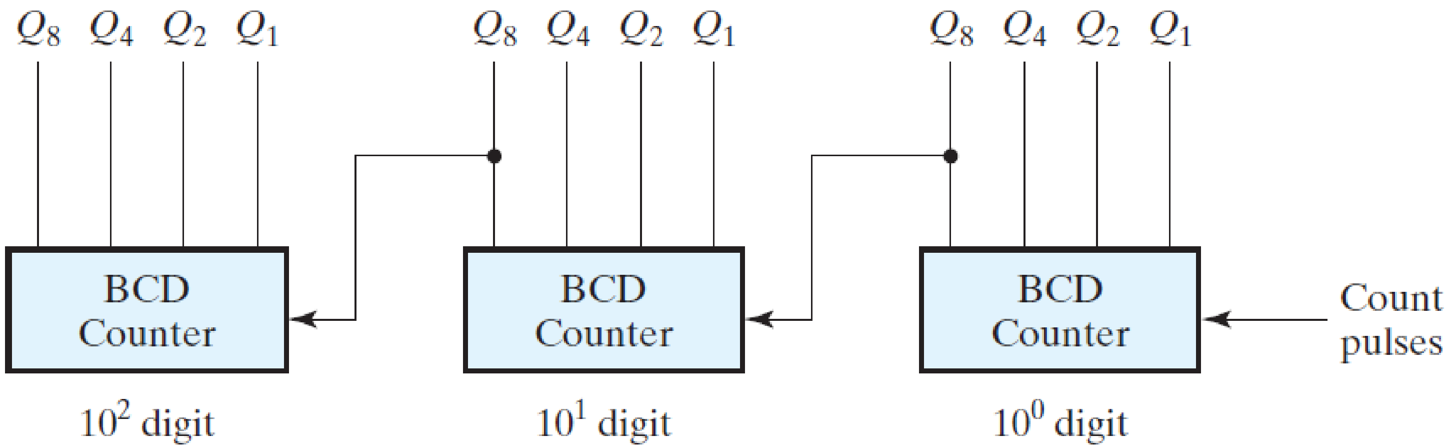
Present State				Next State				Output	Flip-Flop Inputs			
Q_8	Q_4	Q_2	Q_1	Q_8	Q_4	Q_2	Q_1	y	TQ_8	TQ_4	TQ_2	TQ_1
0	0	0	0	0	0	0	1	0	0	0	0	1
0	0	0	1	0	0	1	0	0	0	0	1	1
0	0	1	0	0	0	1	1	0	0	0	0	1
0	0	1	1	0	1	0	0	0	0	1	1	1
0	1	0	0	0	1	0	1	0	0	0	0	1
0	1	0	1	0	1	1	0	0	0	0	1	1
0	1	1	0	0	1	1	1	0	0	0	0	1
0	1	1	1	1	0	0	0	0	1	1	1	1
1	0	0	0	1	0	0	1	0	0	0	0	1
1	0	0	1	0	0	0	0	1	1	0	0	1

$$T_{Q1} = 1$$
$$T_{Q2} = Q_8'Q_1$$
$$T_{Q4} = Q_2Q_1$$
$$T_{Q8} = Q_8Q_1 + Q_4Q_2Q_1$$
$$y = Q_8Q_1$$

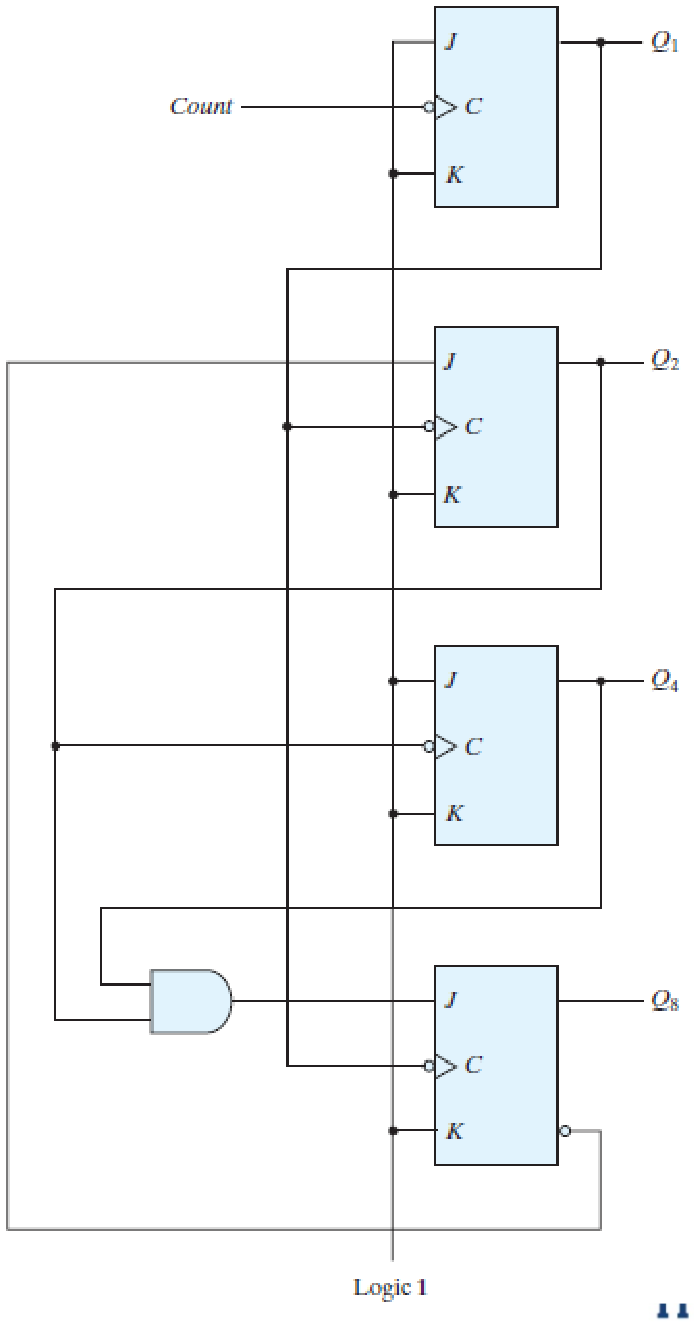
BCD counter (ripple)

In this ripple BCD counter, Q8 goes from 1 to 0 after 10 clock cycles.

This can be used to trigger next decade counter.

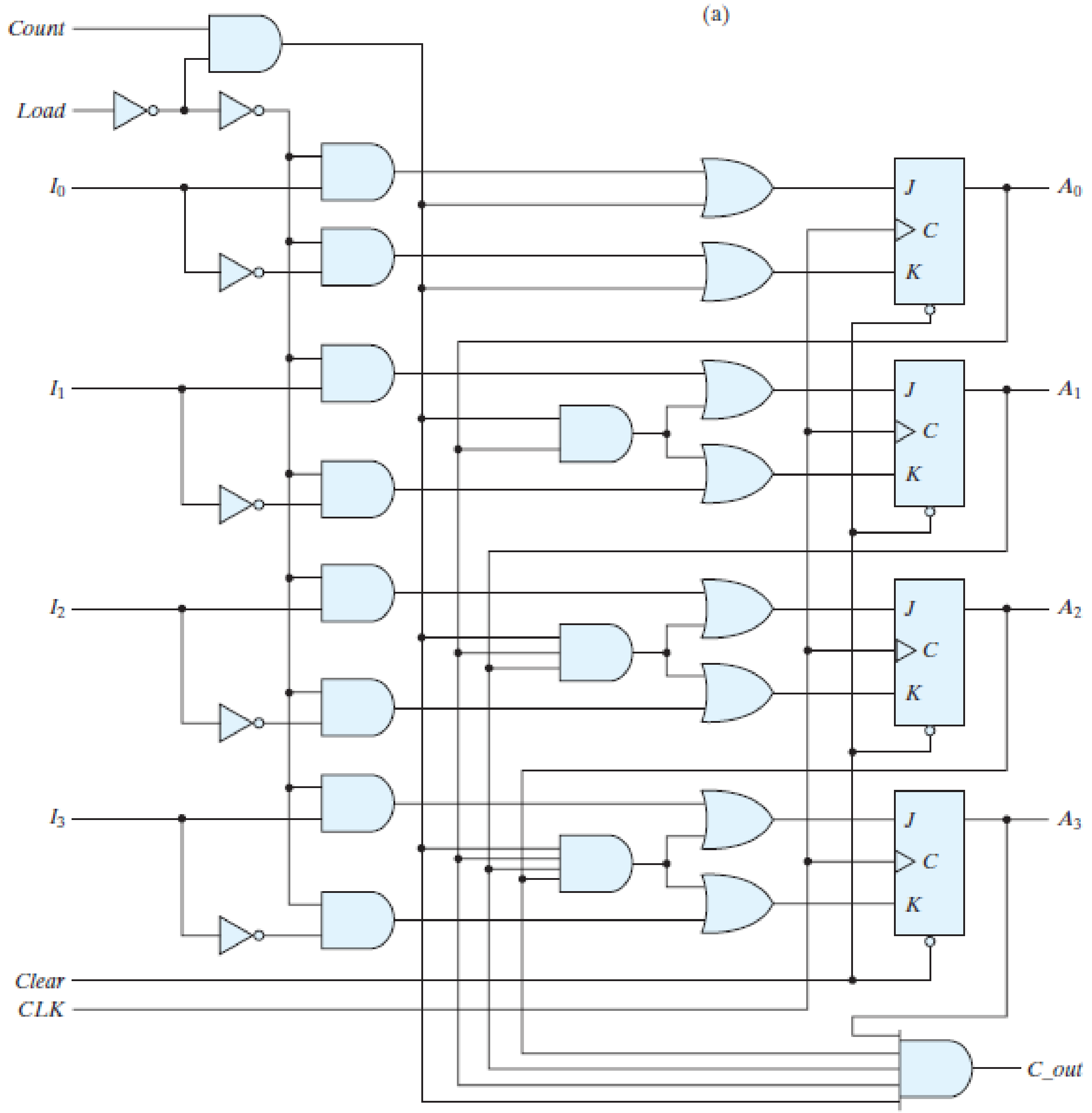


Block diagram of a three-decade decimal BCD counter



Binary counter

This circuit for Binary counter shows that it outputs 1 (C_out) after 16 clock cycles.



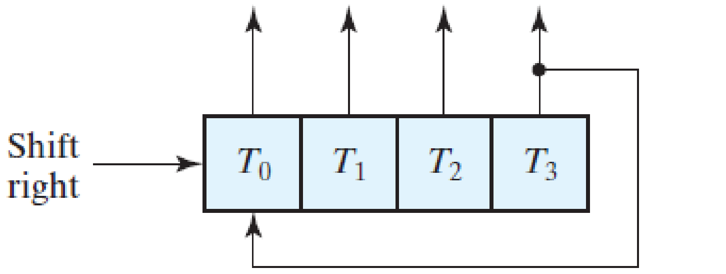
Ring counter

A 4-bit ring counter goes through 4 unique states.

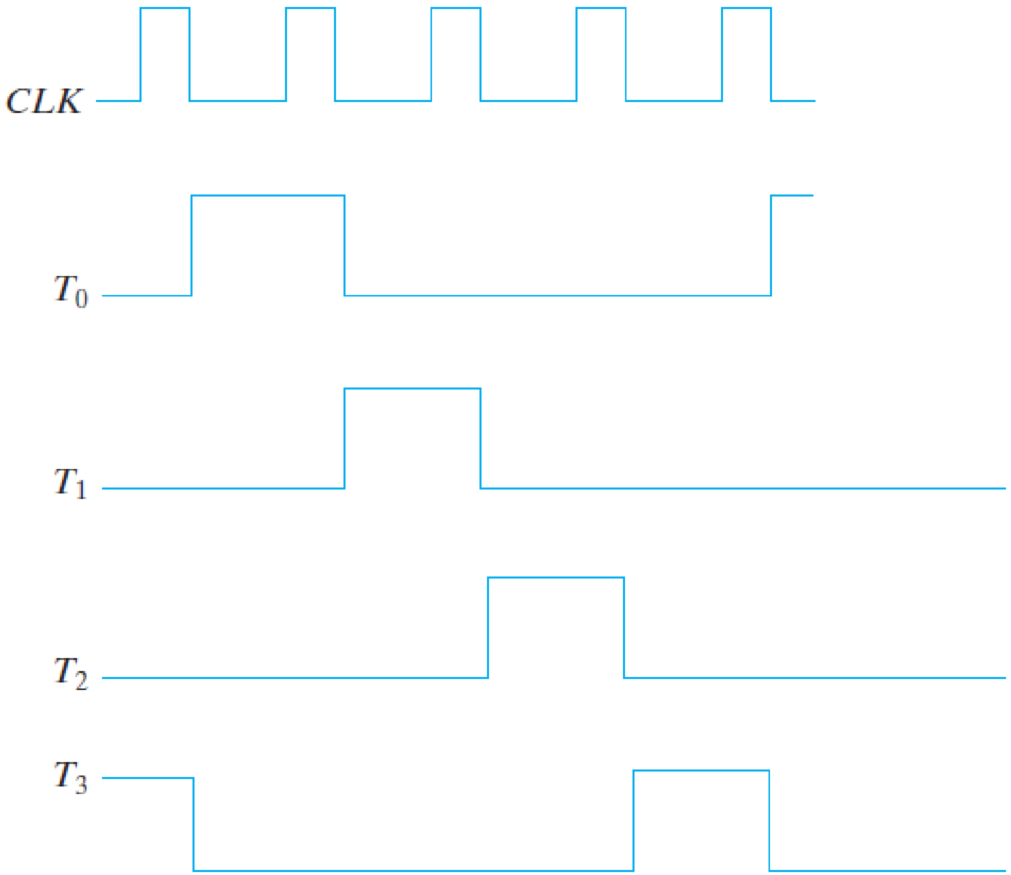
Let Y= T0

Y becomes 1 after 4 cycles.

So, it outputs 1 after 4 clock cycles.



(a) Ring-counter (initial value = 1000)



(b) Sequence of four timing signals

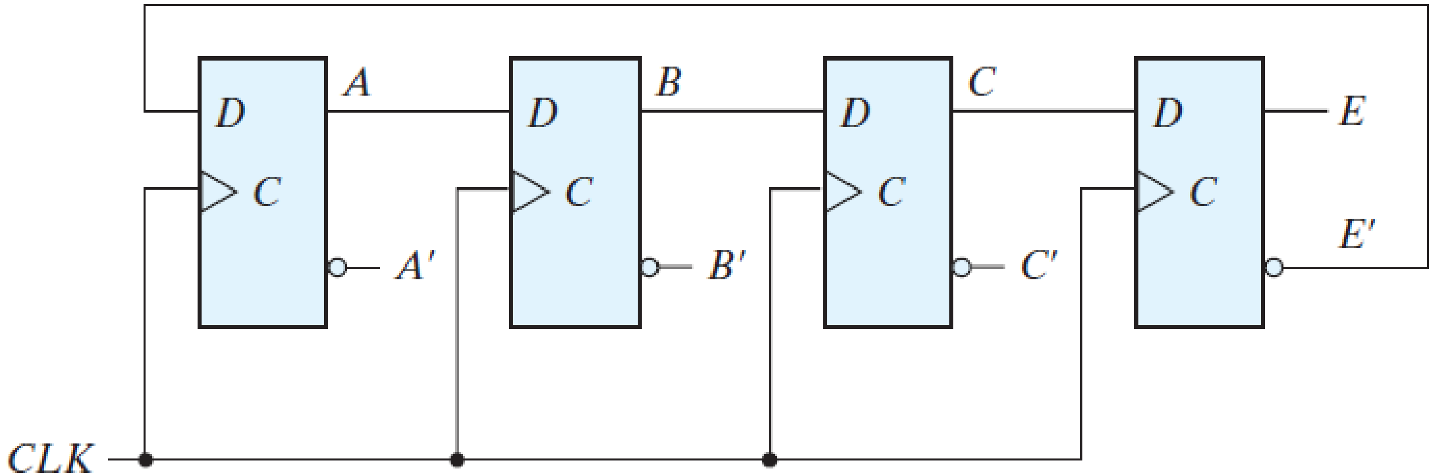
Johnson counter

An N-bit Johnson counter is a modulo-2N counter, because it shows 2N distinct states.

Let Y= A'B'C'E'

Y becomes 1 after 8 cycles.

So, a 4-bit Johnson counter will output 1 after 8 cycles.



(a) Four-stage switch-tail ring counter

Sequence number	Flip-flop outputs			
	A	*B*	*C*	*E*
1	0	0	0	0
2	1	0	0	0
3	1	1	0	0
4	1	1	1	0
5	1	1	1	1
6	0	1	1	1
7	0	0	1	1
8	0	0	0	1