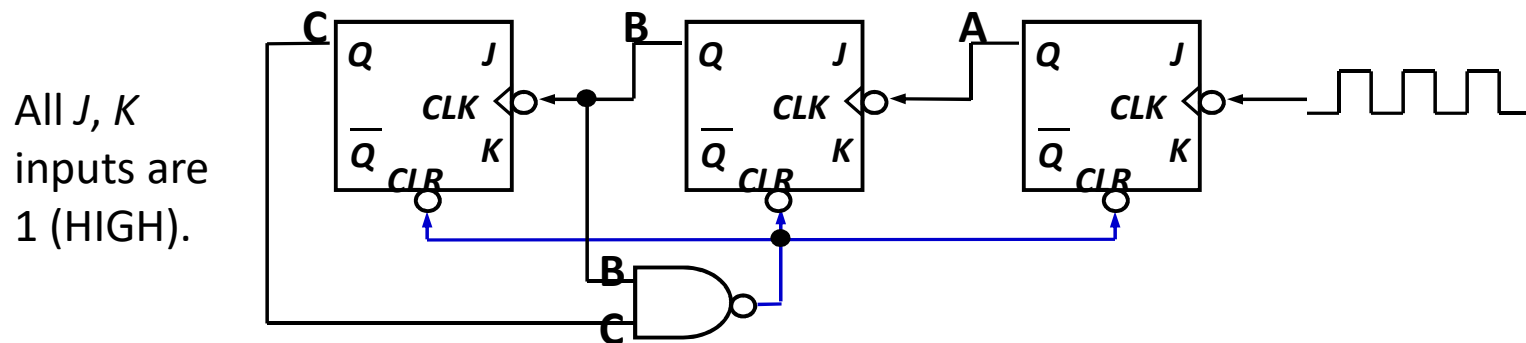


# **Sequential Circuit (Asynchronous Counter Design)**

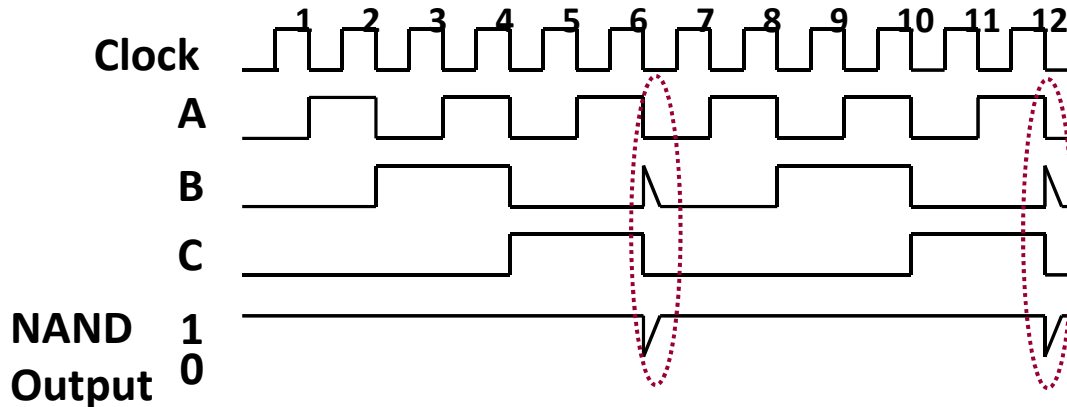
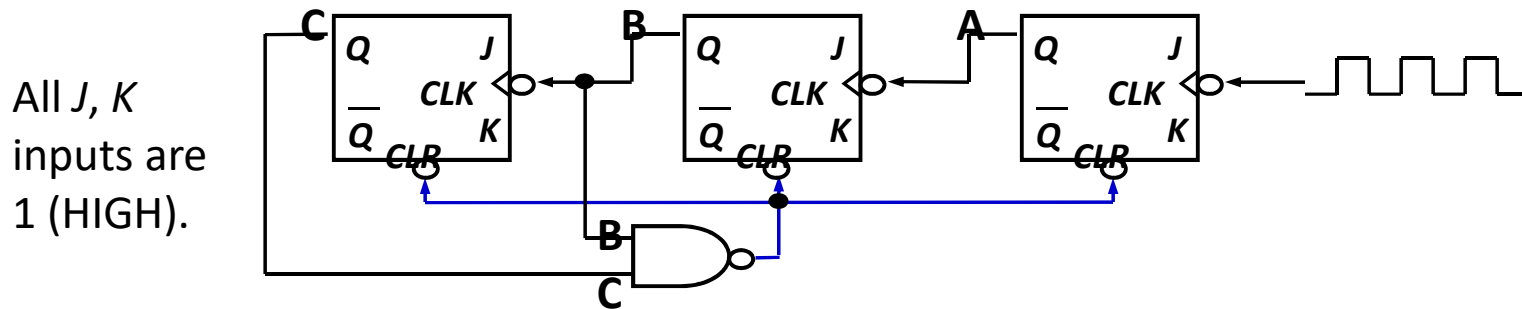
## Asyn. Counters with MOD no. $< 2^n$

- States may be skipped resulting in a **truncated sequence**.
- Technique: force counter to *recycle before going through all of the states* in the binary sequence.
- Example: Given the following circuit, determine the counting sequence (and hence the modulus no.)



# Cont...

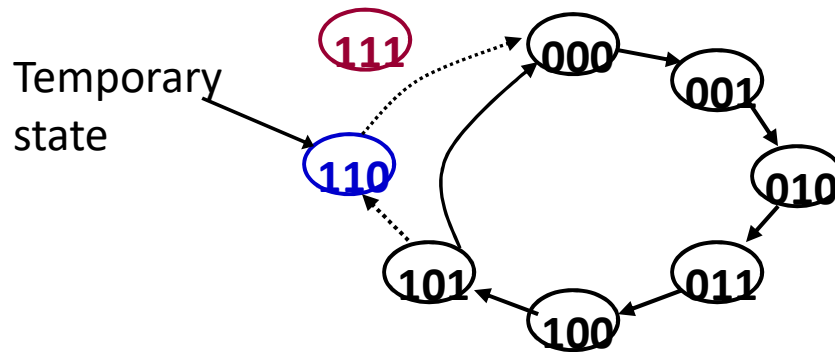
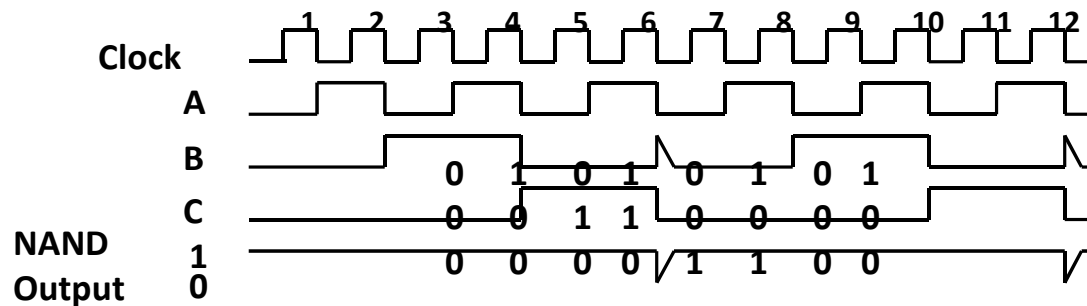
## Example (cont'd):



**MOD-6 counter**  
produced by clearing  
(a MOD-8 binary  
counter) when count  
of six (110) occurs.

## Asyn. Counters with MOD no. $< 2^n$

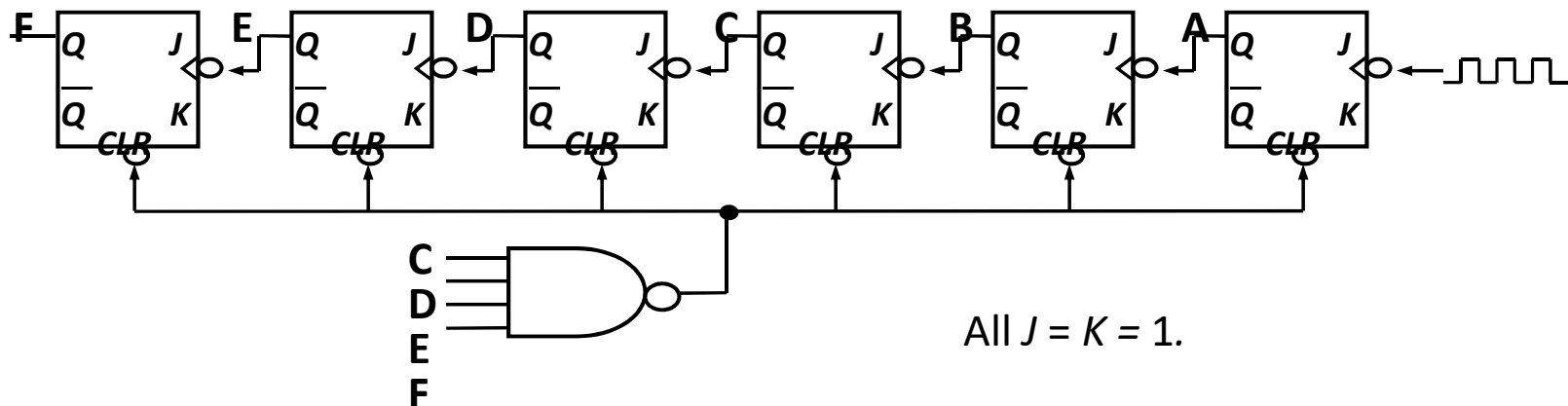
Example (cont'd): Counting sequence of circuit (in CBA order).



Counter is a MOD-6 counter.

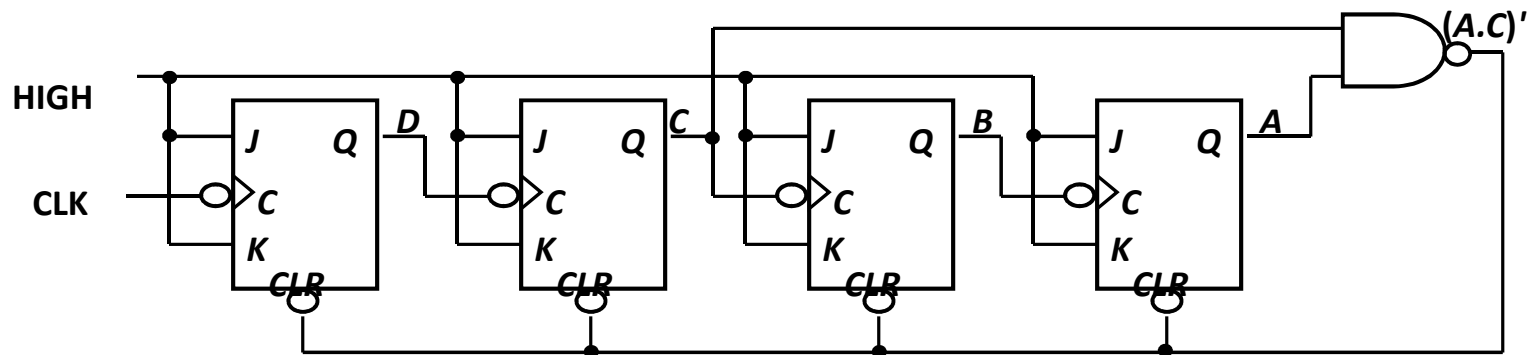
## Asyn. Counters with MOD no. $< 2^n$

- *Exercise:* How to construct an asynchronous MOD-5 counter? MOD-7 counter? MOD-12 counter?
- *Question:* The following is a MOD-? counter?



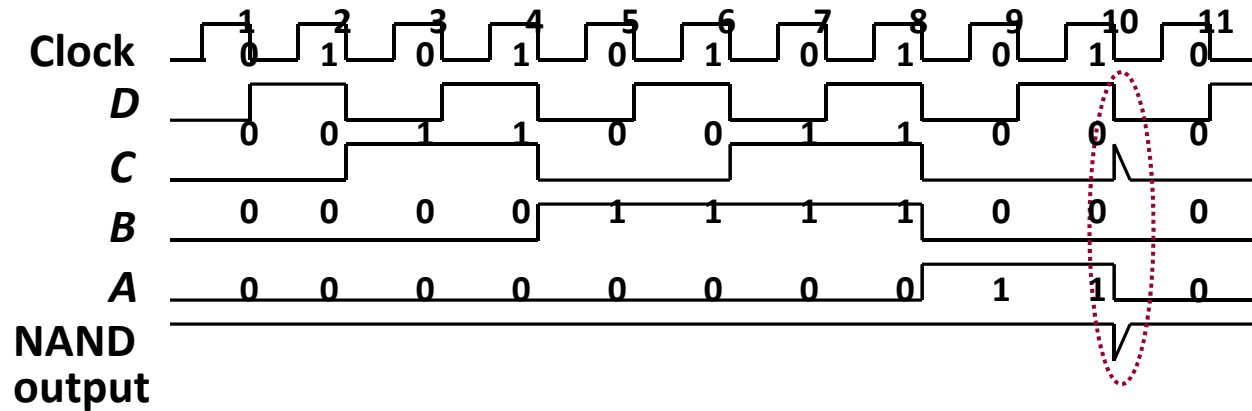
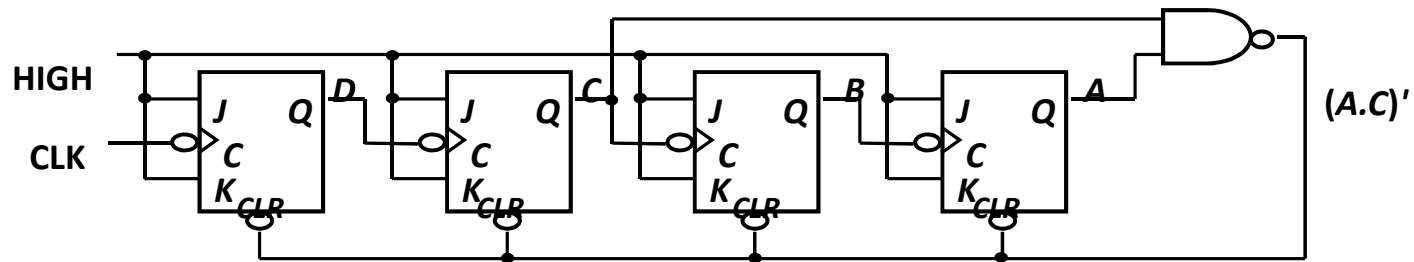
## Asyn. Counters with MOD no. $< 2^n$

- **Decade counters** (or **BCD counters**) are counters with 10 states (modulus-10) in their sequence. They are commonly used in daily life (e.g.: utility meters, odometers, etc.).
- Design an asynchronous decade counter.



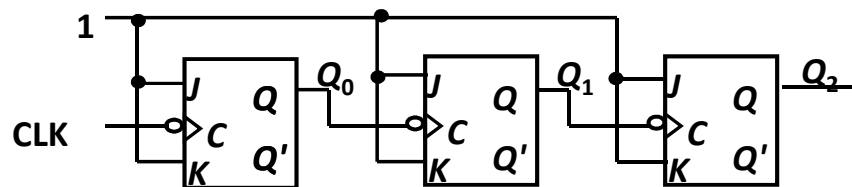
## Asyn. Counters with MOD no. $< 2^n$

- Asynchronous decade/BCD counter (cont'd).

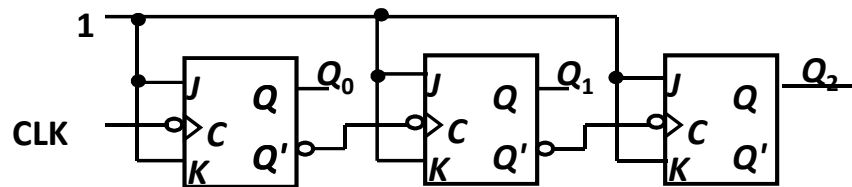


## Asynchronous Down Counters

- So far we are dealing with *up counters*. *Down counters*, on the other hand, count downward from a maximum value to zero, and repeat.
- Example: A 3-bit binary (MOD- $2^3$ ) down counter.



3-bit binary  
up counter

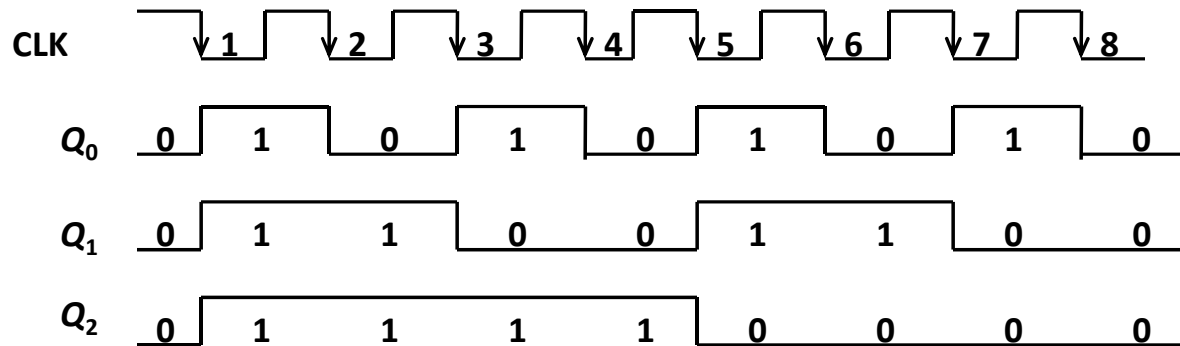
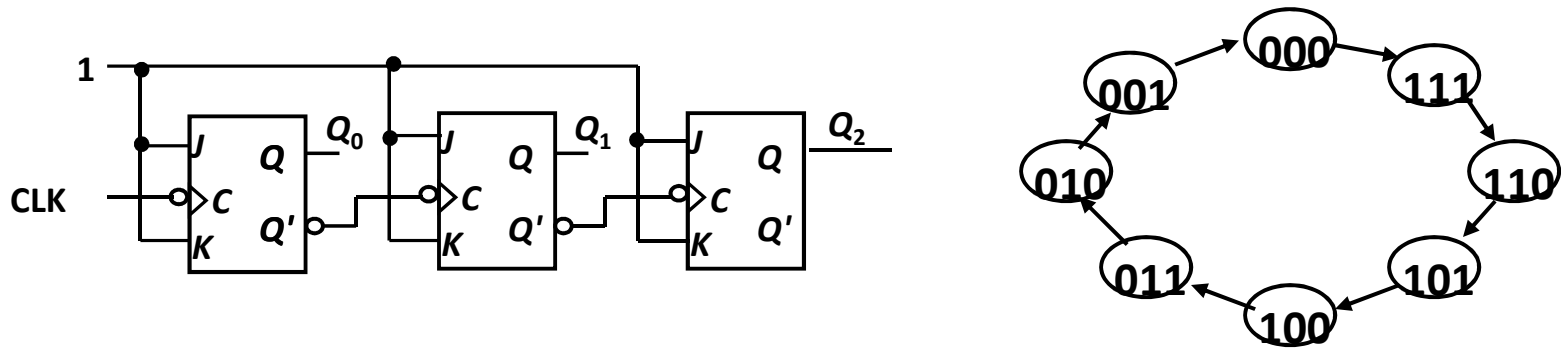


3-bit binary  
down counter



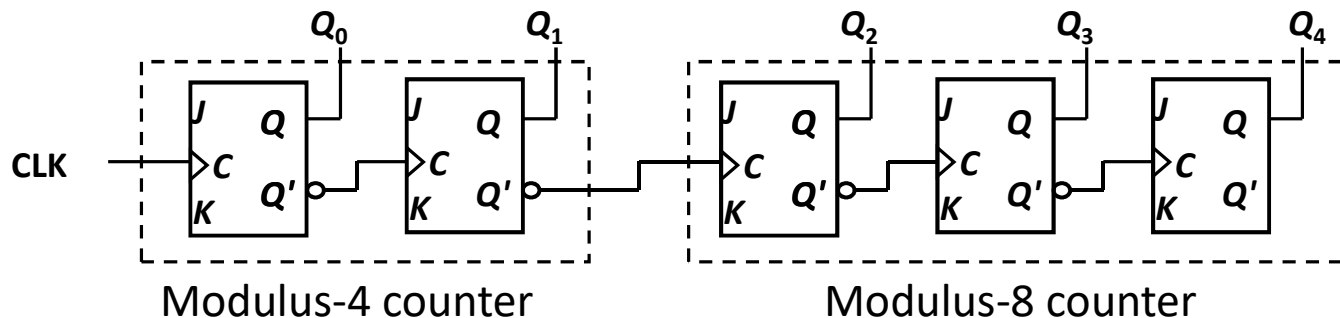
# Asynchronous Down Counters

- Example: A 3-bit binary (MOD-8) down counter.



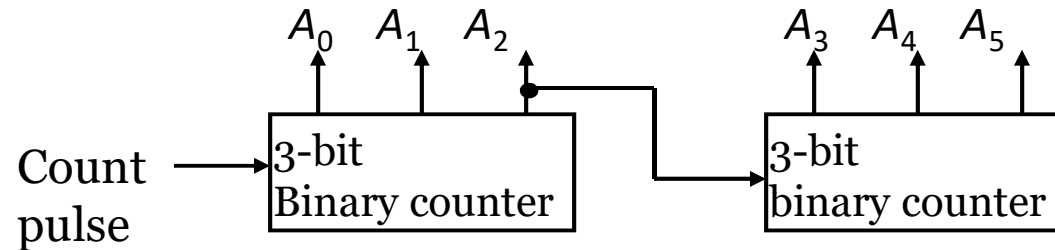
## Cascading Asynchronous Counters

- Larger asynchronous (ripple) counter can be constructed by cascading smaller ripple counters.
- Connect last-stage output of one counter to the clock input of next counter so as to achieve higher-modulus operation.
- Example: A modulus-32 ripple counter constructed from a modulus-4 counter and a modulus-8 counter.



## Cascading Asynchronous Counters

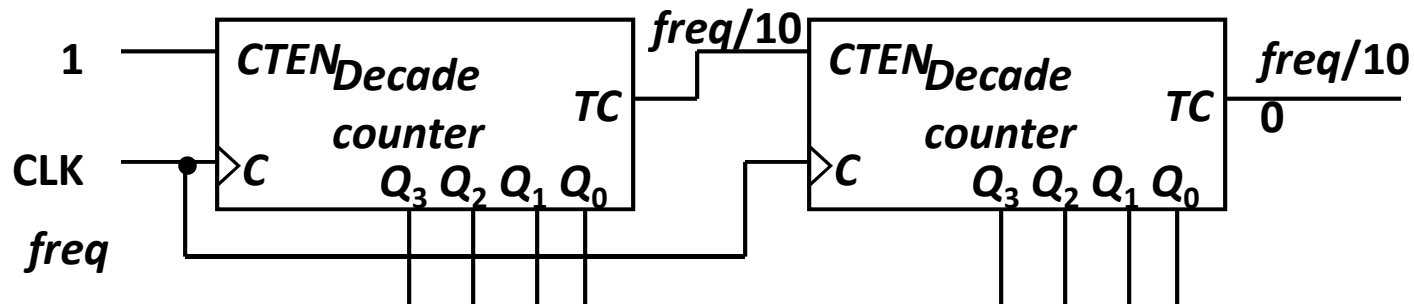
- Example: A 6-bit binary counter (counts from 0 to 63) constructed from two 3-bit counters.



$A_5$	$A_4$	$A_3$	$A_2$	$A_1$	$A_0$
0	0	0	0	0	0
0	0	0	0	0	1
0	0	0	:	:	:
0	0	0	1	1	1
0	0	1	0	0	0
0	0	1	0	0	1
:	:	:	:	:	:

## Cascading Asynchronous Counters

- If counter is not a binary counter, requires additional output.
- Example: A modulus-100 counter using two decade counters.



**$TC = 1$  when counter recycles to 0000**