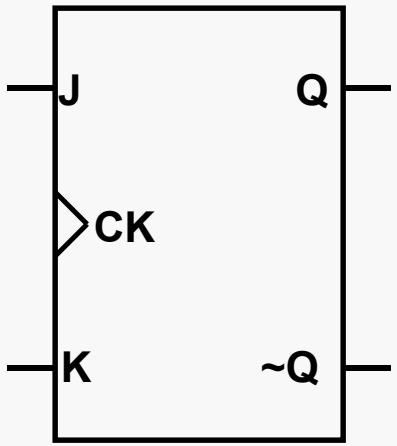
JK Flip-flop

The JK flip-flop takes two data inputs and updates its state Q, on a clock tick, according to the table:

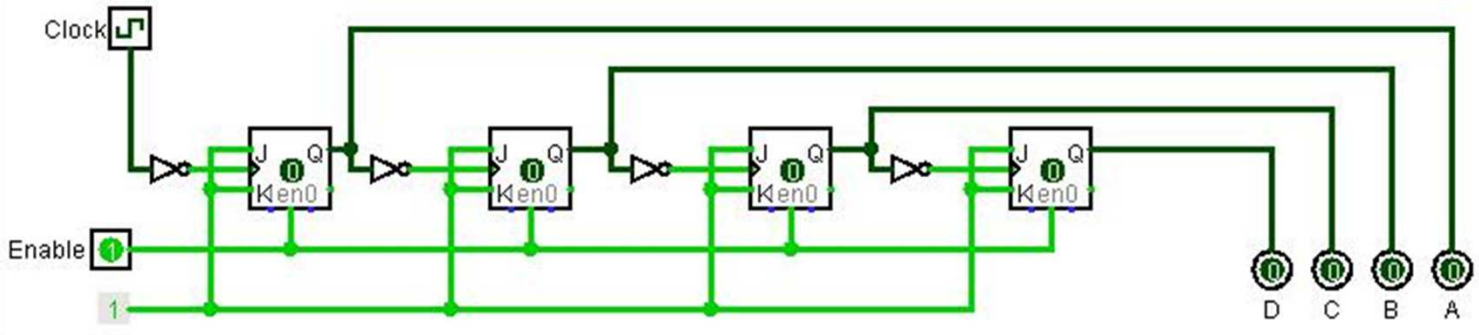
J	K	Q	~Q
0	0	no change	
0	1	0	1
1	0	1	0
1	1	opposite	



In Logisim and the following diagrams, the JK flip-flops update state on the rising edge (when the clock goes from low to high).

A mod-16 Counter

We can use JK flip-flops to implement a 4-bit counter:

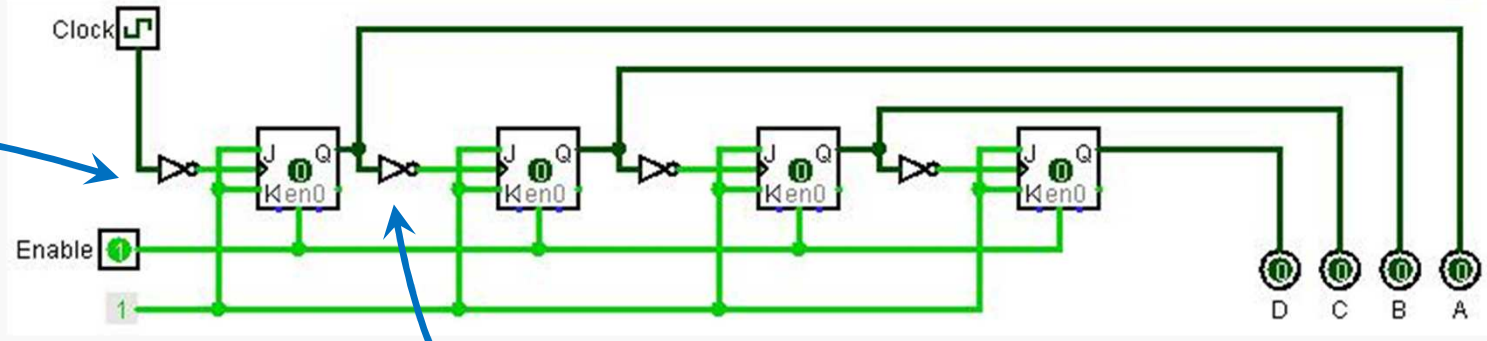


Note that the J and K inputs are all set to the fixed value 1, so the flip-flops "toggle".

As the clock signal runs, the circuit will cycle its outputs through the values
0000, 0001, 0010, . . . , 1111
and then repeat the pattern.
So, it counts clock ticks, modulo 16.

mod-16 Counter: first tick

Suppose the counter is in the initial state shown below (output is 0000).



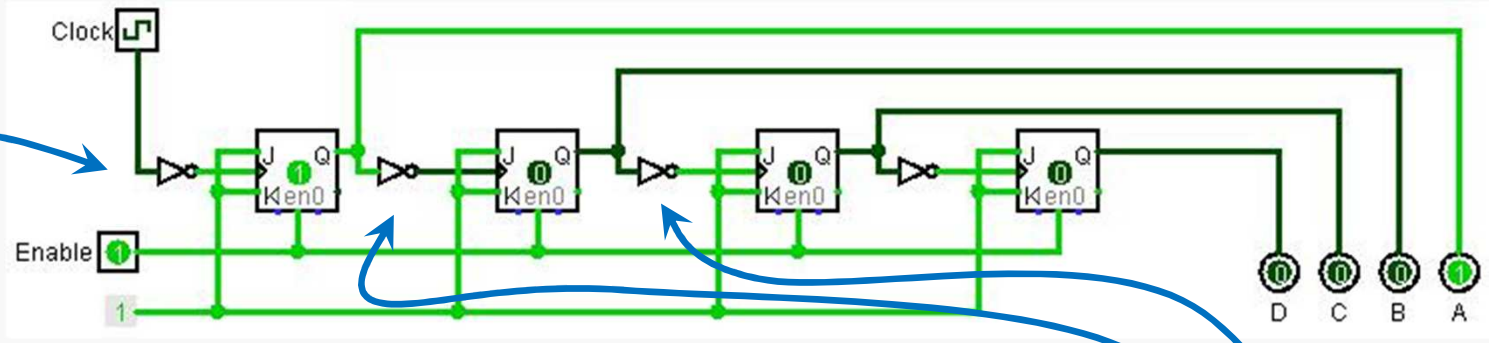
When the clock cycles from high to low:

- the left-most sees its (inverted) clock signal go from low to high, and so it toggles its state to 1
- the next flip-flop sees its clock signal go from high to low, and so it doesn't toggle
- and so, neither do the other flip-flops…

So, the output is 0001.

mod-16 Counter: second tick

Suppose the counter is now in the state shown below (output is 0001).



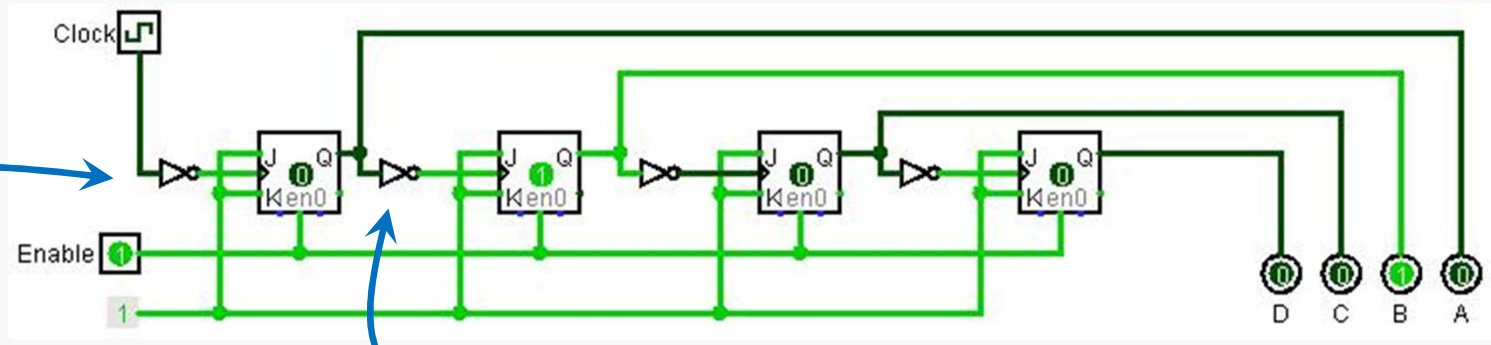
When the clock cycles from high to low (2nd cycle):

- the left-most sees its (inverted) clock signal go from low to high, and so it toggles its state to 0
- the next flip-flop sees its clock signal go from low to high, and so it toggles its state to 1
- the next flip-flop sees its clock signal go from high to low, so it doesn't toggle

So the output is 0010.

mod-16 Counter: third tick

Suppose the counter is now in the state shown below (output is 0010).



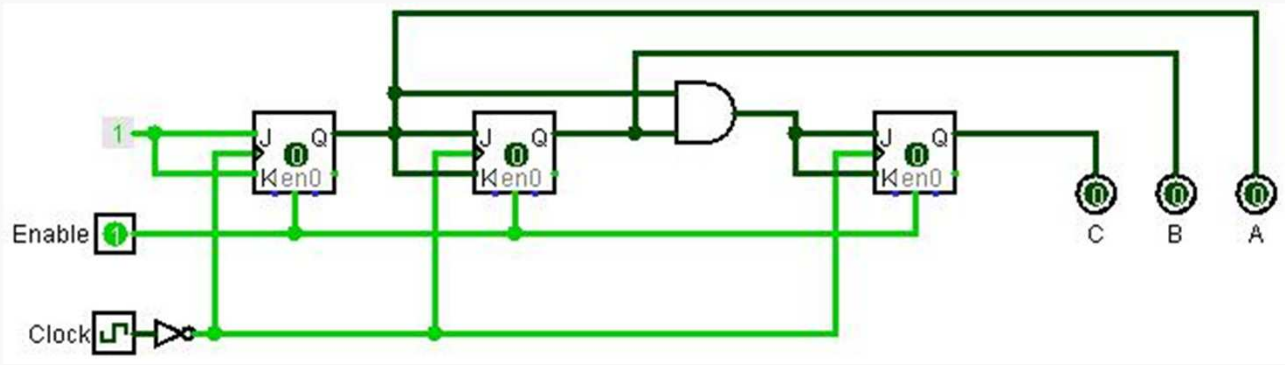
When the clock cycles from high to low (3rd cycle):

- the left-most sees its (inverted) clock signal go from low to high, and so it toggles its state to 1
- the next flip-flop sees its clock signal go from high to low, and so it doesn't toggle

So the output is 0011.

A mod-8 Parallel Counter

We can use JK flip-flops to implement a 3-bit parallel counter:



As the clock signal runs, the circuit will cycle its outputs through the values

000, 001, 010, . . . , 111

and then repeat the pattern.

So, it counts clock ticks, modulo 8.