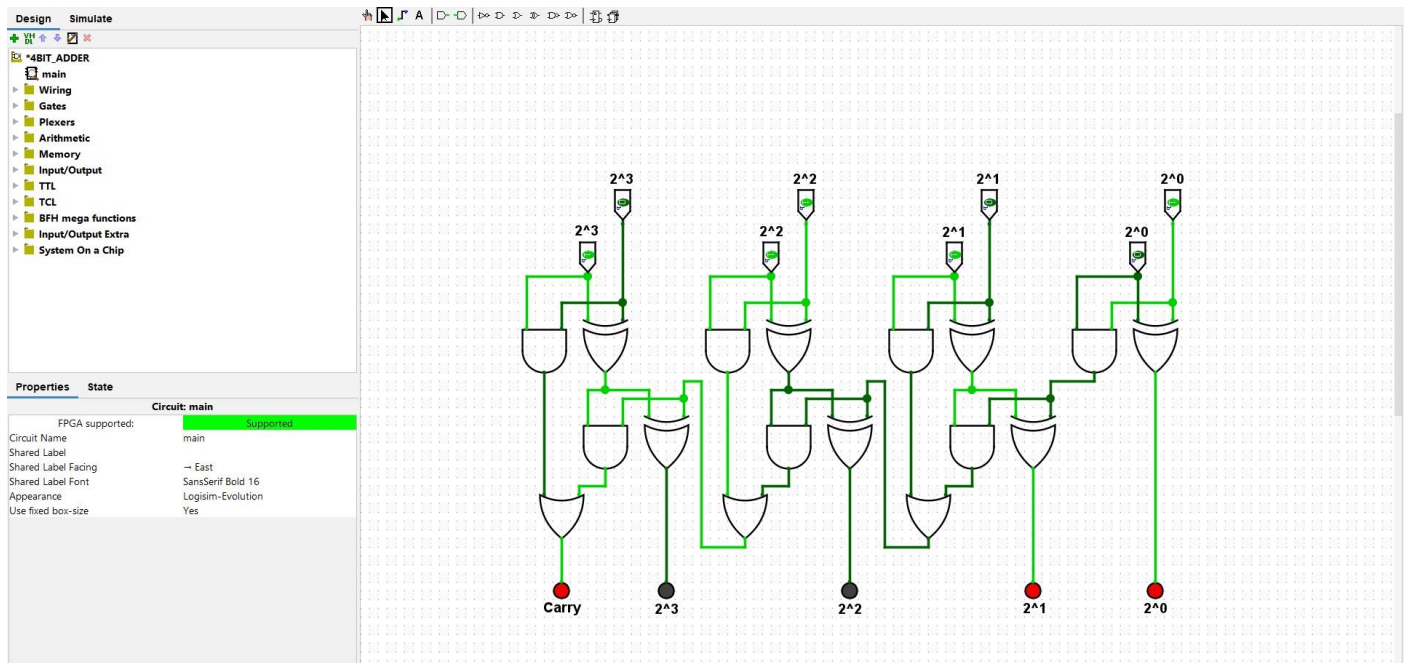


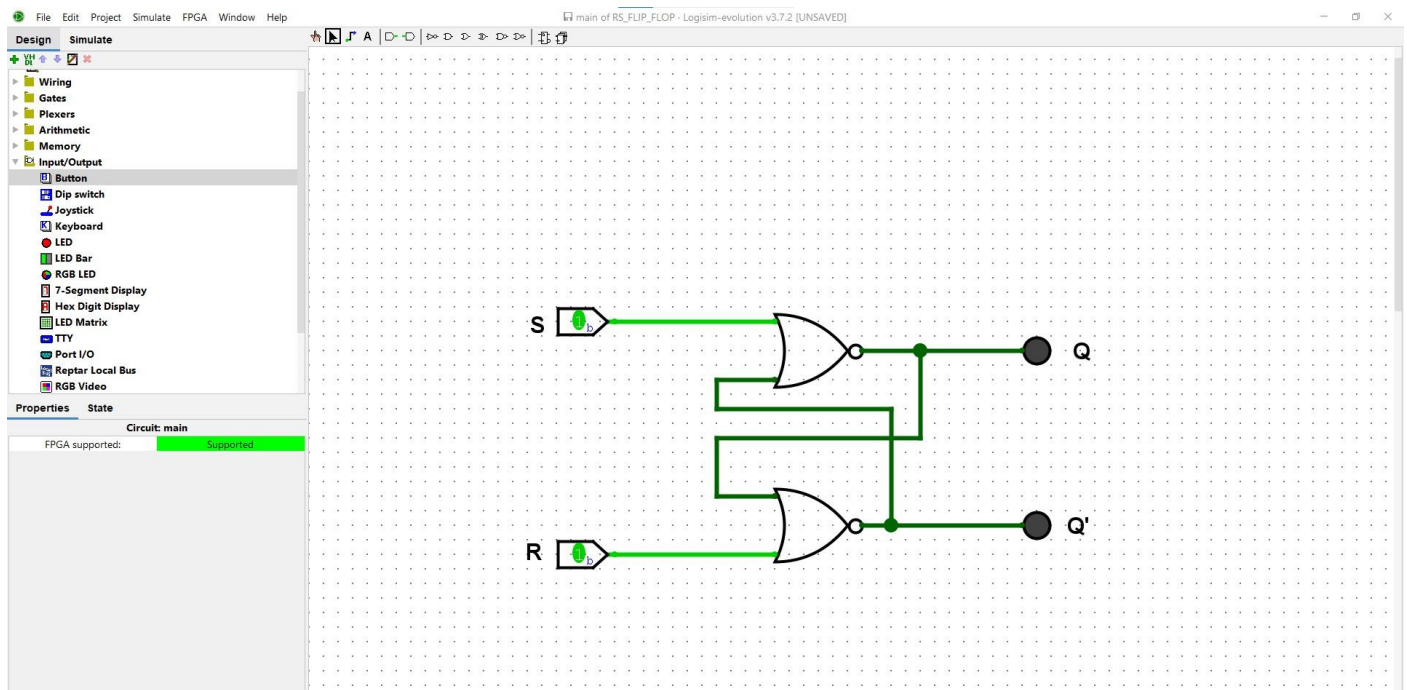
I – 4-bit Adder:



Truth table

Input A	Input B	Output (without carry)
0101	0000	0101
0101	0001	0110
0101	0010	0111
0101	0011	1000
0101	0100	1001
0101	0101	1010
0101	0110	1011
0101	0111	1100
0101	1000	1101
0101	1001	1110
0101	1010	1111
0101	1011	0000
0101	1100	0001
0101	1101	0010
0101	1110	0011
0101	1111	0100

II – RS Flip-flop



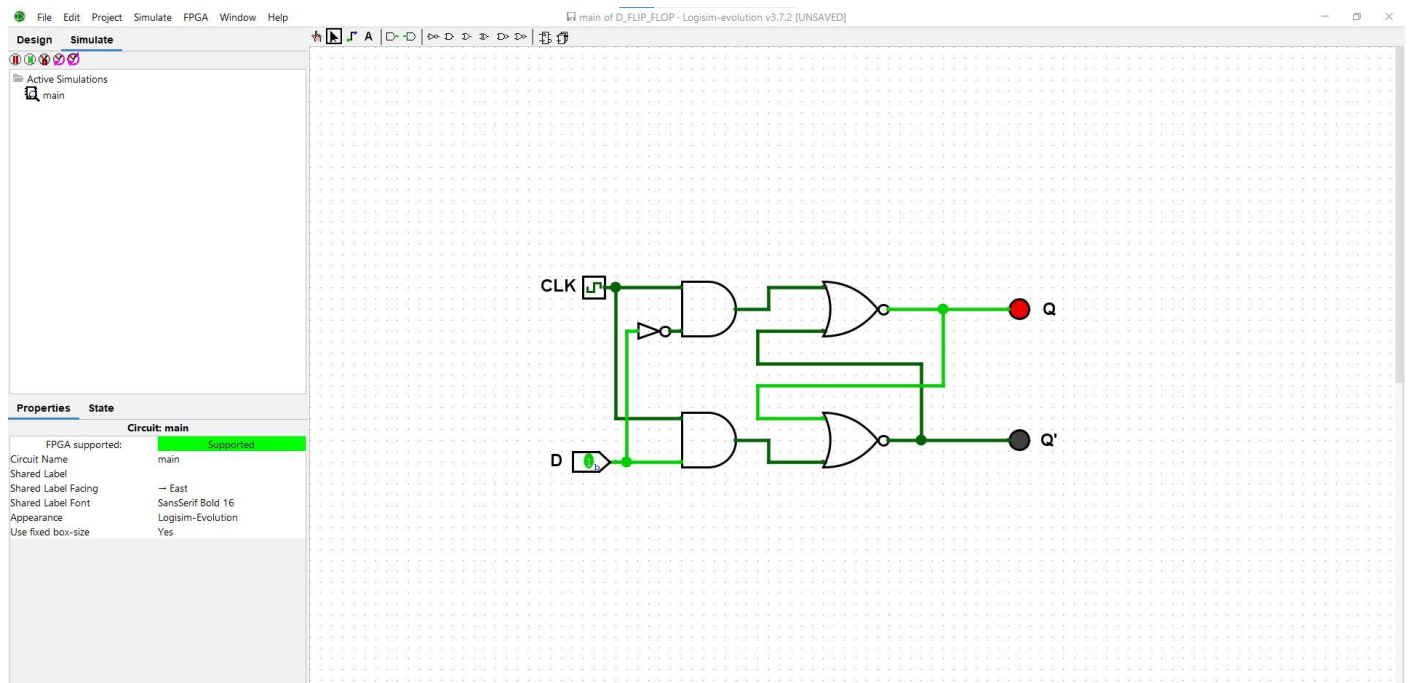
Truth table

Set	Reset	Q	Q'
1	0	0	1
1	1	0	0
0	1	1	0
1	1	0	0

When one of the inputs is 1, the circuit is in one of two stable states (on or off), which is useful because it now stores one bit of data (0 or 1).

When both inputs are 1, due to the nature of the NOR gates, the output bits Q and Q' are both 0. This violates the relationship $Q = \text{not } Q'$. In circuit design, if both Q and Q' are the same, race conditions may occur.

III – D Flip-flop:



Truth table

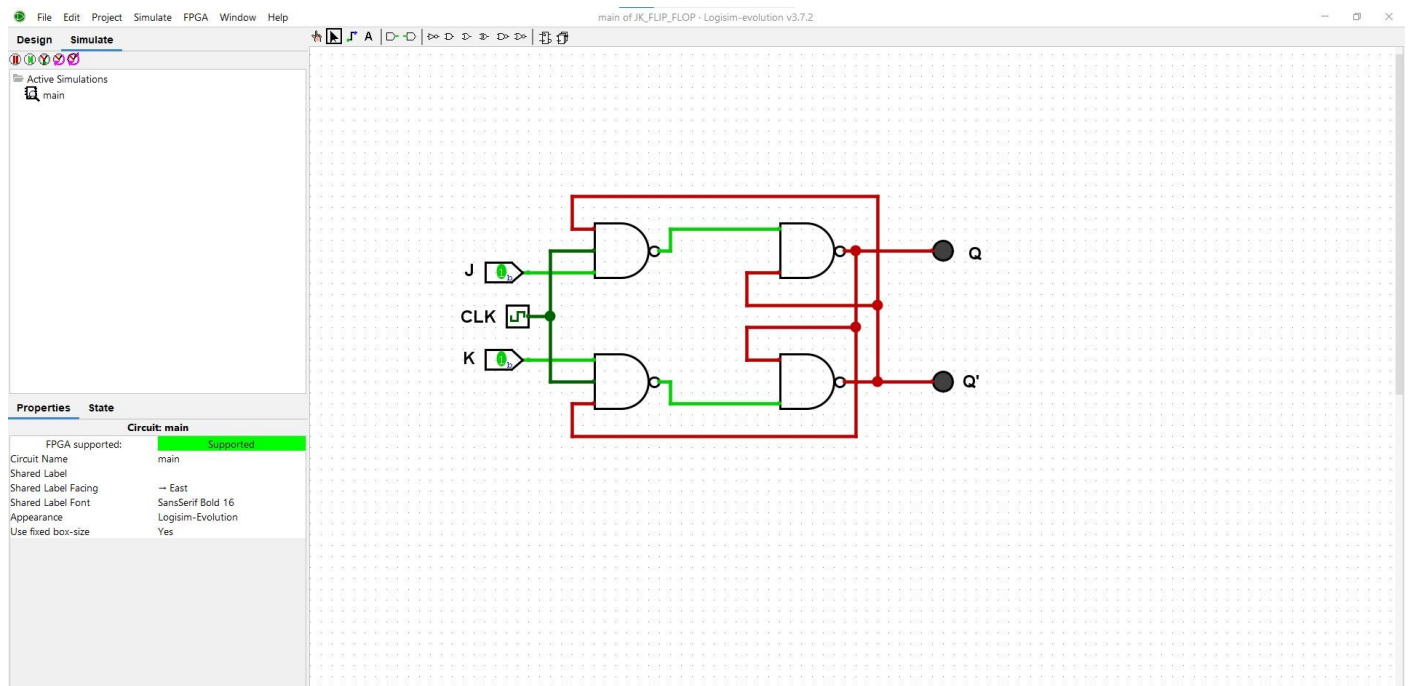
Clock	Pin	Q	Q'
0	0	Unchanged	
0	1		
1	0	0	1
1	1	1	0

The D Flip-flop stores the value of input pin D on every clock pulse. It is useful in circuit design because it is a synchronous circuit that does not have an indeterminate state.

The role of the clock in the D Flip-flop is to prevent the outputs Q and Q' from changing immediately when input D change. Q and Q' will only change on the rising edge or falling edge of the clock, depending on the setup.

The D Flip-flop is preferred over the RS Flip-flop because it does not have an indeterminate state where both outputs Q and Q' are the same.

IV – JK Flip-flop



Truth table

J	K	Q (when clocked)	Q' (when clocked)
0	0	Unchanged	
1	0	1	0
0	1	0	1
1	1	not Q_{N-1}	not Q'_{N-1}

In order to make a JK Flip-Flop behave like a D Flip-Flop, we feed J the value of D and feed K the inverted value of D. When D is 0, J will be 0 and K will be 1, thus resetting the state of Q to 0. When D is 1, J will be 1 and K will be 0, thus setting the state of Q to 1.

In order to make a JK Flip-Flop behave like a T Flip-Flop, we feed both J and K the value of T. When T is 0, both J and K will be 0, maintaining the state of the flip-flop. When T is 1, both J and K will be 1, toggling the values of Q and Q'.