1 Lecture 1 - Course Introduction/Bits and Bytes

2 Lecture 2- Logic Gates

3 Lecture 3 - Binary Arithemetic

4 Lecture 4 - Combinational Logic

5 Lecture 5 - Flip Flops

5.1 Clicker Question

Consider a multiplexer shown, what must the inpust A,B,C,D be so that the multiplexer output is

$$X = S_1 \cdot S_0 + \bar{S_1} \cdot G$$

5.2 Circuits that remember values

The output of any logic gate or combinational circuit is dependent on the inputs. If an input changes, the output can also change. The previous value is lost forever.

5.3 Memory Element: D Flip Flop

- D is input
- Q is output
- CLK (clock) is control input.

How does it work? Q copies the value of D (remembers it) whenever CLK goes from 0 to 1 (rising edge).

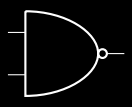
5.4 Characteristic Tables

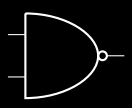
Characteristic table defines operation of flip-flop in tabular form.a

5.5 D Flip-flops

Definition 1. A n bit **register** can be made using n D flip-flops.

5.6 Latches from NAND gates



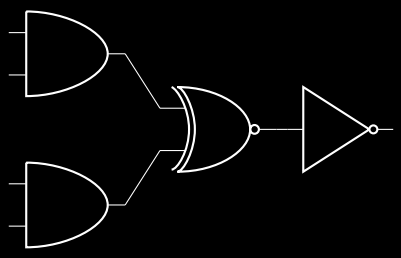


5.7 Flip-Flops vs Latches

Any devices based on edges are referred to as flip flops, these are edge-triggered devices.

Triangle indicates edge-triggered (therefore flip-flop)

State of the flip flop is the value stored. Flip-flops are more useful than latches.



6 Lecture 6 - Sequential Circuits (Shift Registers)