Digital Design

Week 4: Sequential Circuits
Part I

Fenerbahce University

Instructors

Instructor: Dr. Vecdi Emre Levent

Office: 311

Email : emre.levent@fbu.edu.tr

R.A. Ugur Ozbalkan

Office: 311

Email : ugur.ozbalkan@fbu.edu.tr

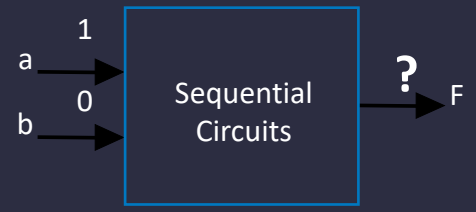
Course

- Sequential Circuits

Sequential Circuits

- Sequential Circuits
  - *In sequential circuit, the output depends not only on the current inputs, but also on previous inputs.*
  - Example : Counter counting up with a summation circuit

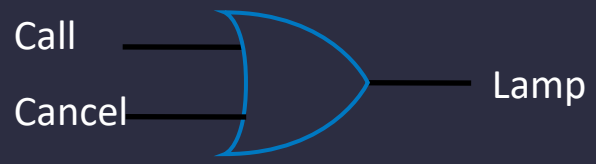
- Memory storage unit called flip-flop



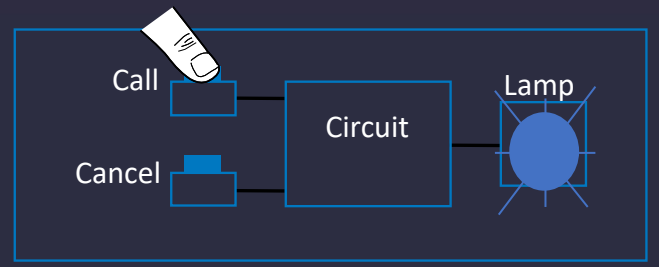
Sequential Circuits

- Flight attendant call button
  - When pressed, the lamp remains active until it is pressed again.
  - When pressed again, the lamp turns off

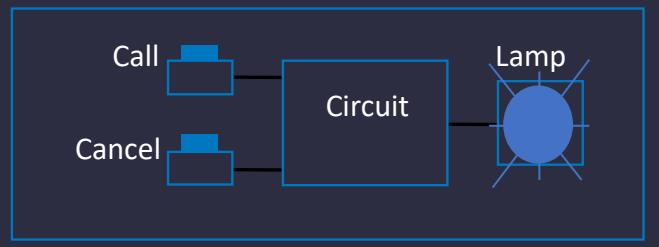
combinatorial circuits?



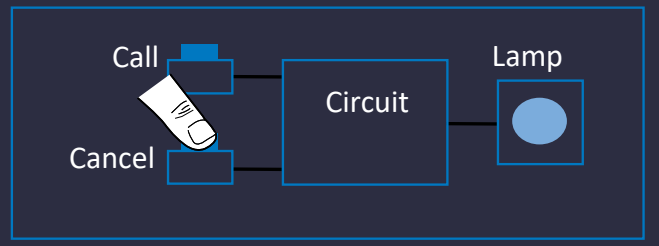
It will not work because the lamp will only be 1 when the call is pressed. The lamp will turn to 0 when the call button is not pressed. A register that holds the previous state of the circuit is needed for the desired behavior



1. Button pressed, light on

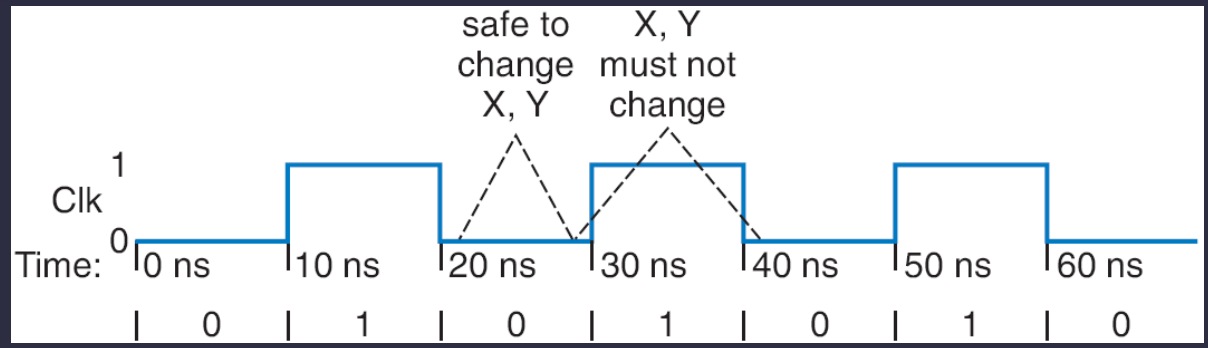


2. The button is released, the light remains on



3. Canceled, light off

Sequential Circuits

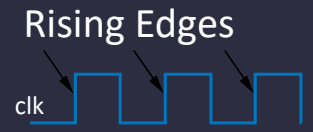


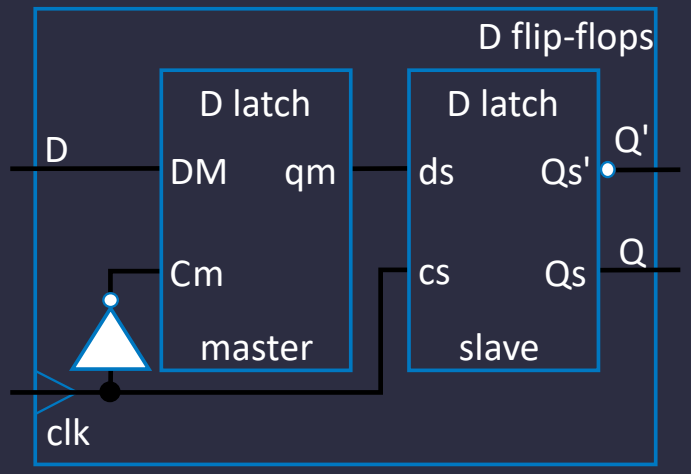
- ***Clock Period*** : The time between two rising edges
  - Period of the above signal : 20 ns
- ***Clock cycle*** :
  - Number of rising edge
- ***Clock Frequency*** : 1/ period
  - The period of the above signal = 1/20 ns = 50 MHZ

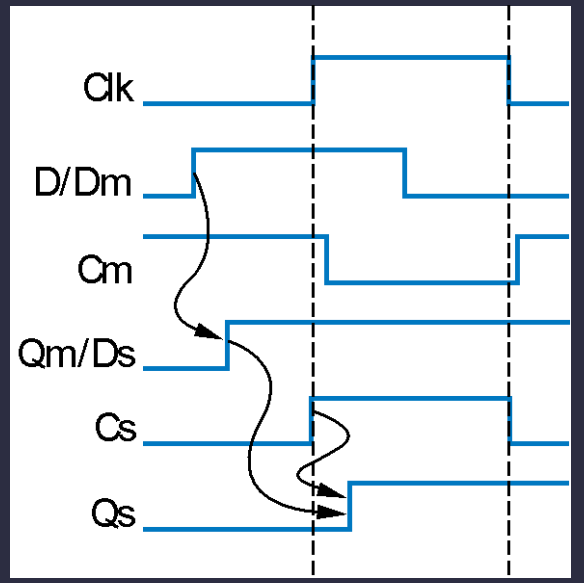
Freq	Period
100GHz	0.01 ns
10GHz	0.1 ns
1GHz	1 ns
100MHz	10 ns
10MHz	100 ns

Sequential Circuits

- ***Flip-flop*** : Samples the signal coming from outside on the rising edge of the incoming clock
- Design example – master - slave
  - 2 D latch is used.

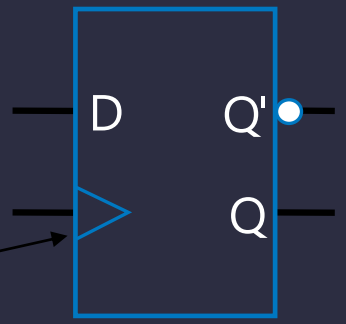




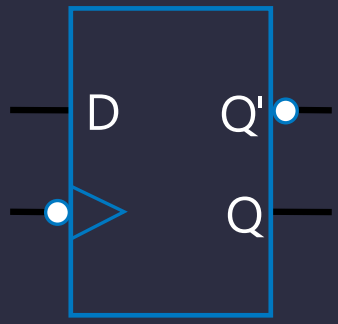


Sequential Circuits

The triangle represents the clock input.



Rising Edge active flip flop notation



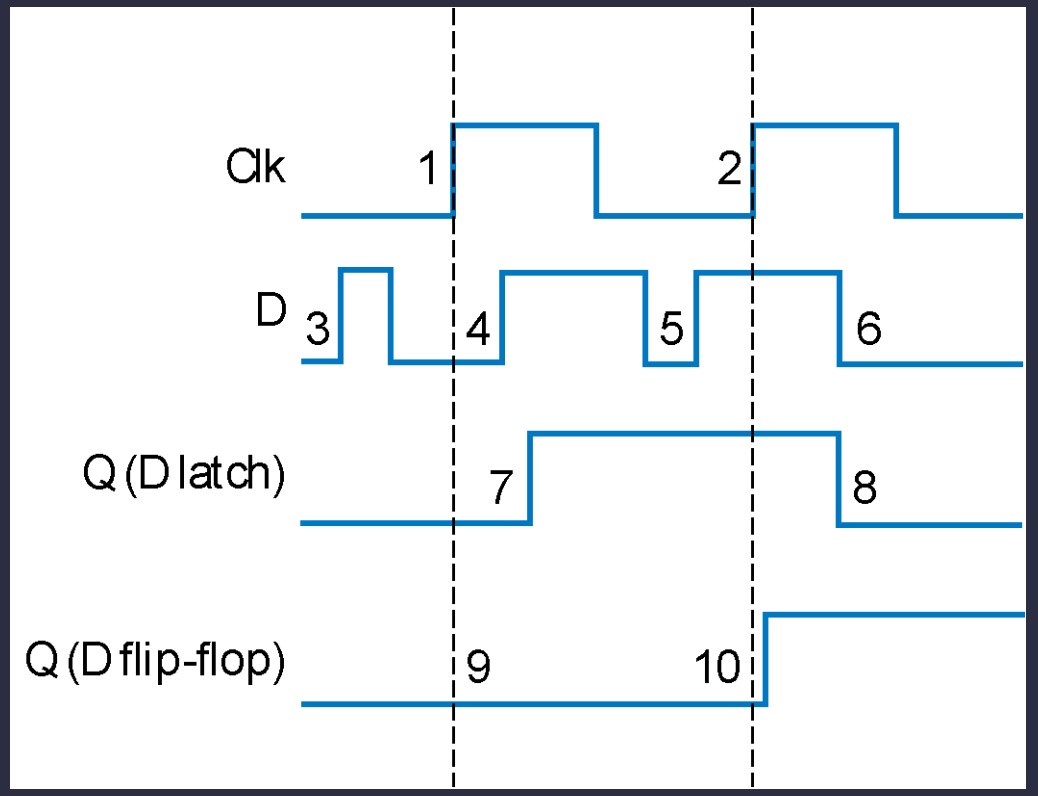
Falling Edge active flip flop notation

Rising Edges
(Positive edge)

Falling Edges
(negative edge)

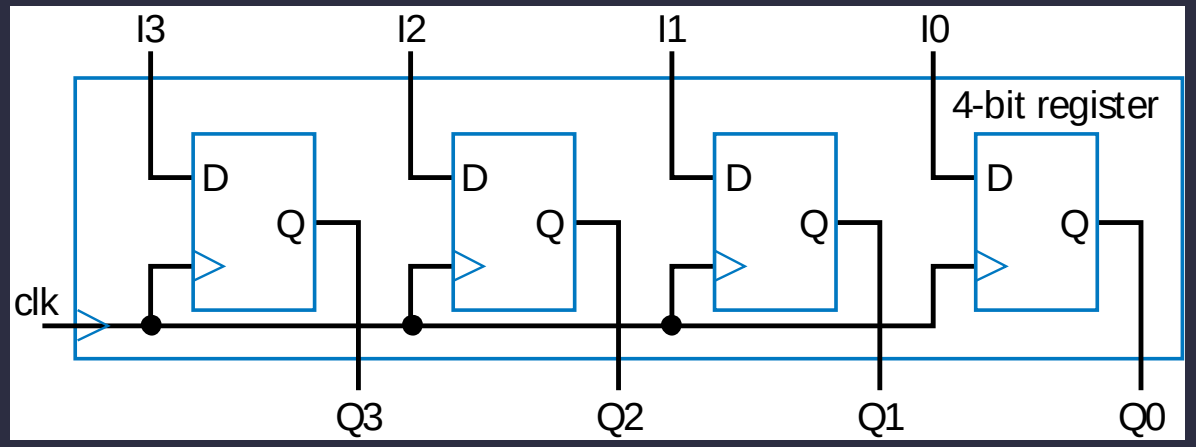
Sequential Circuits

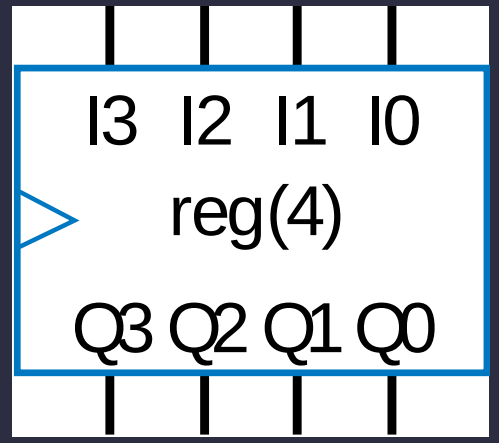
- D latch
- D -flip flop



Sequential Circuits

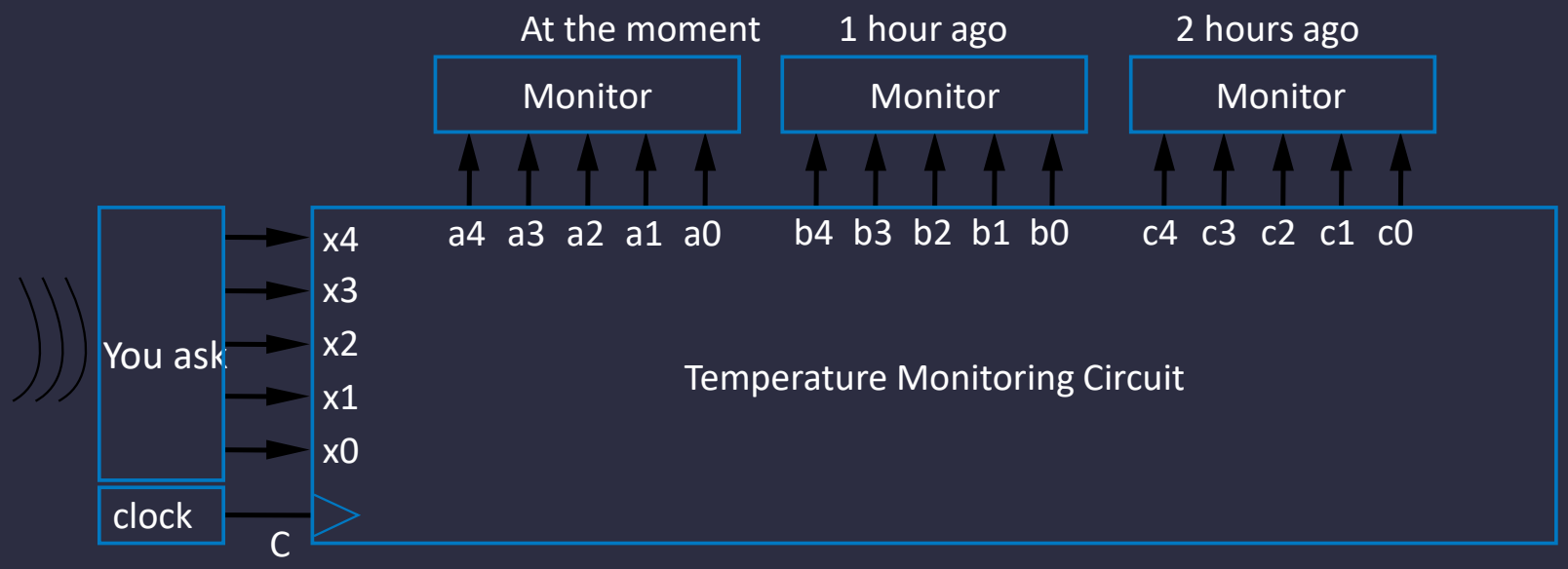
- When multiple bits need to be held, D flip flops are used together.
  - For example, when a 4-bit number needs to be kept
- Multi flip ***Register*** to the structure where the flops are held together *it is called*.

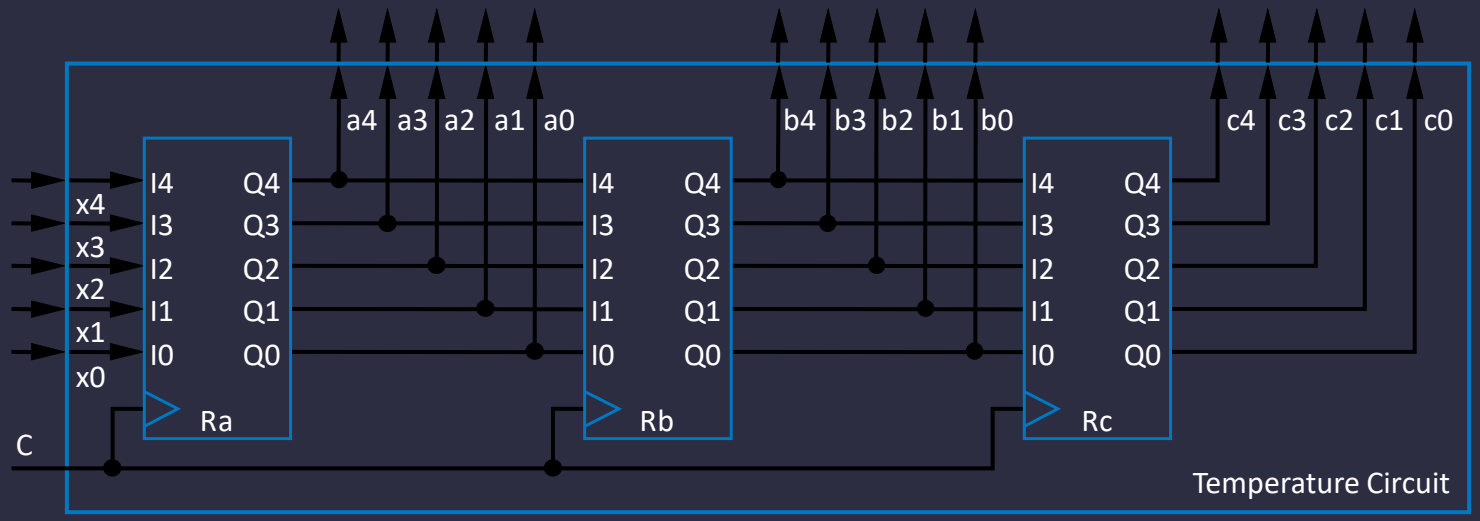
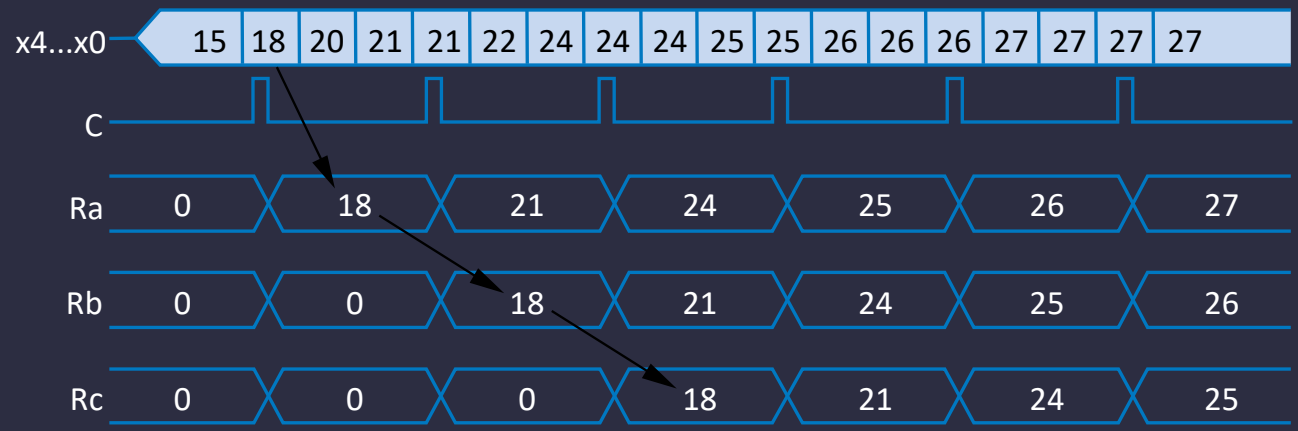




Sequential Circuits

- Temperature Circuit
  - Temperature sensor gives a 5 bit output.
  - Clock's period is 1 hour. (It's a pretty slow clock)
  - Each clock on the rising edge and displays it to the monitor.



Sequential Circuits

- 5bit registers