



Birla Institute of Technology & Science, Pilani
Hyderabad Campus

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CS/ECE/EEE/INSTR F215:Digital Design

Lecture 19: *Introduction to Sequential Circuits* *Tue, 12 Oct 2021*

BITS Pilani

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IT IS NEVER TOO LATE

TO START HEADING IN THE RIGHT DIRECTION

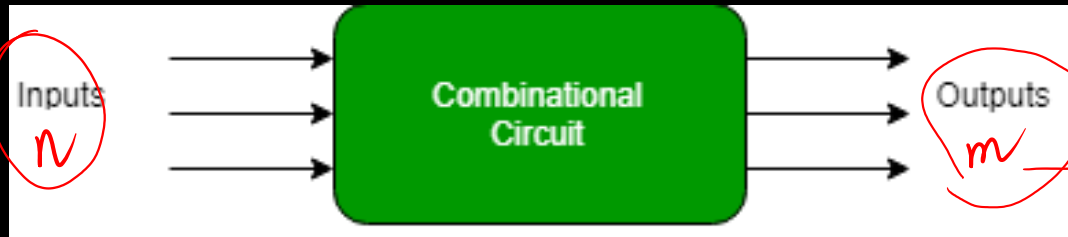


Logic Circuits

Combinational

Sequential

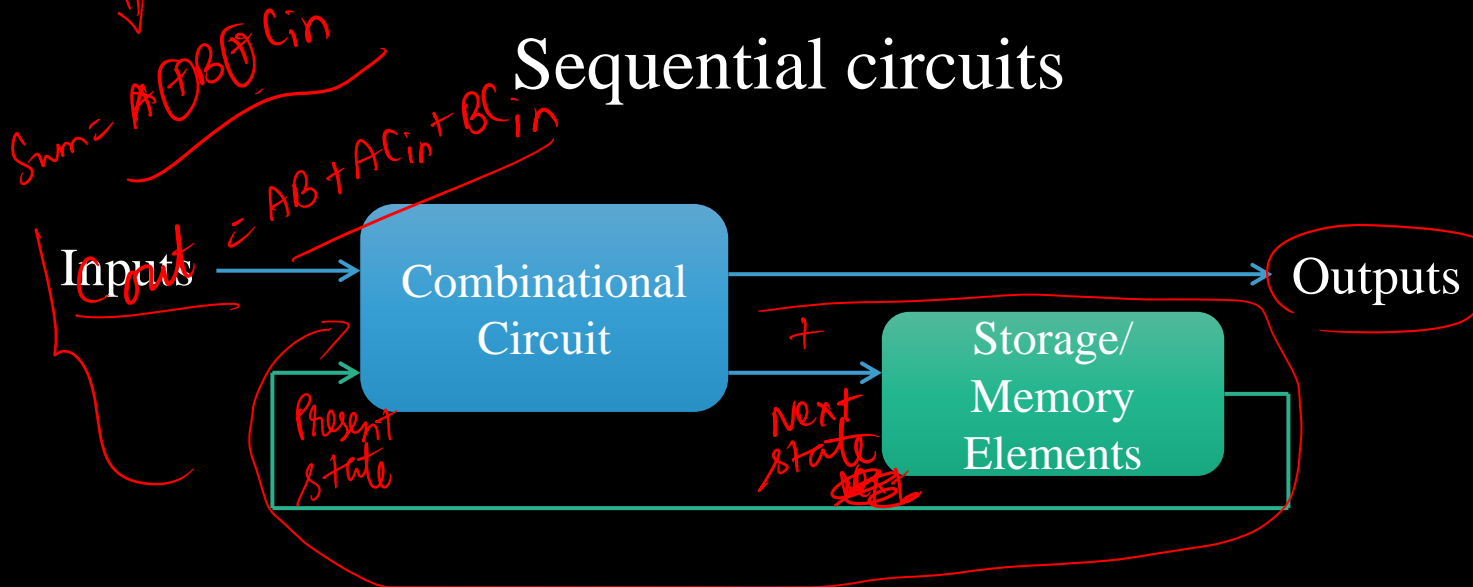
Combinational circuits – The outputs at any time are a function of only the present inputs



Full adder
3 i/p's
2 o/p's
A, B, Cin
Sum, Cout
 $\Rightarrow 2^3 = 8$

2^n combinations of i/p's
Boolean functions

Sequential circuits

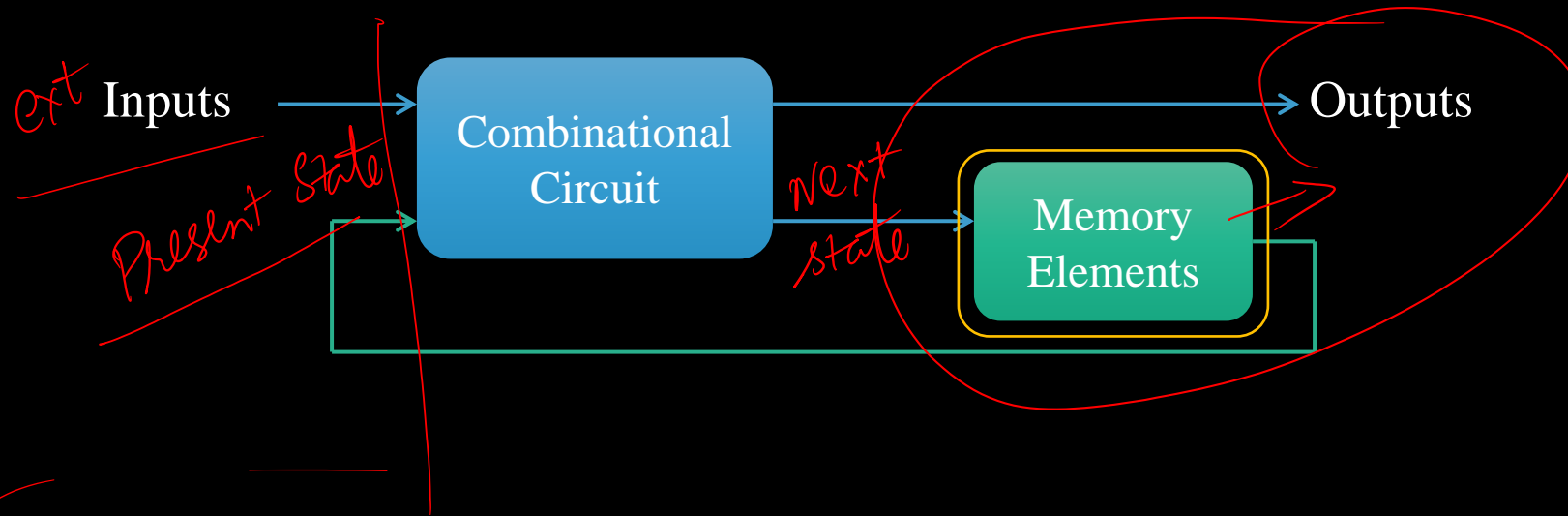


feed back
o/p is fed
back to
the i/p

Sequential logic circuits

- Consists of combinational logic circuit to which ^{memory} storage elements are connected to form a feedback path
- Outputs are a function of ^{external} inputs and the state of the storage elements.
- As the state of the storage element is a function of previous inputs to the circuit, outputs of a sequential circuit at any time depend not only on the present values of inputs but also on past inputs.
- Circuit behaviour is specified by a time sequence of inputs and internal states.

Sequential logic circuits



Digital camera

logic high SET state
logic low RESET state

Storage / Memory elements, capable of storing **binary information**

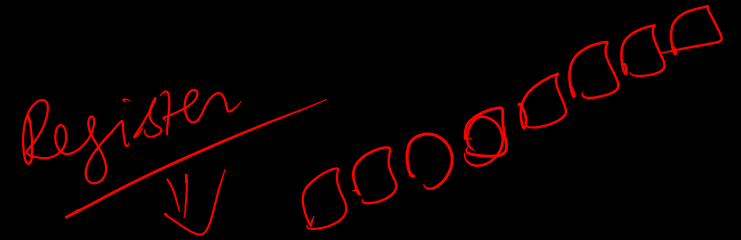
Binary information stored at any given time → **state of the sequential circuit** at that time

External input + present state → Determine **output** of sequential circuit

External input + present state → Determine **next state** of memory element

Storage / Memory elements

- It should be able to hold a value
- One should be able to read the value stored
- One should be able to change the value.



Latches and flip-flops are the basic elements for storing information. A latch or flip-flop can store one bit of information.

- Maintain a binary state indefinitely until directed by an input signal to change state.
- Has two useful states.

1 → set state
0 → reset state

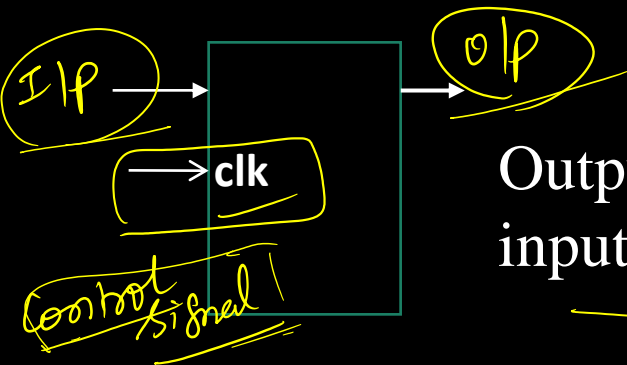
set & Reset
'1' '0'

Bistable

1
0

Latches and flip-flops \Rightarrow storage elements

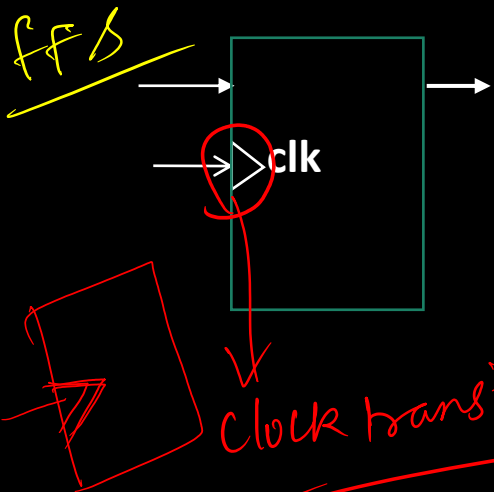
- Storage elements that operate with signal levels (level sensitive) are **Latches** ^{devices}



Output follow the input as long as the clock input is asserted (**high/low**)

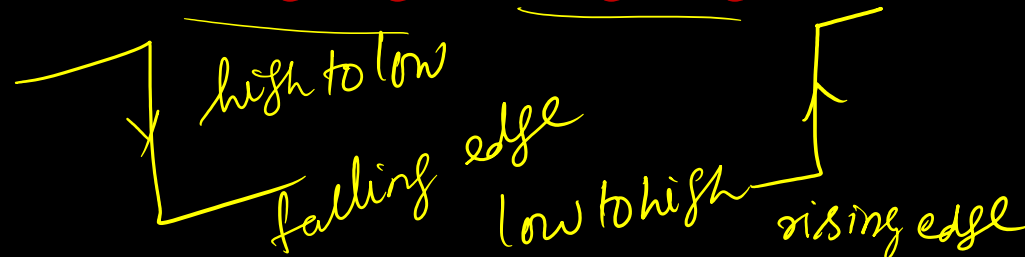


- Storage elements that operate with clock transitions (edge sensitive) are flip-flops ^{devices}

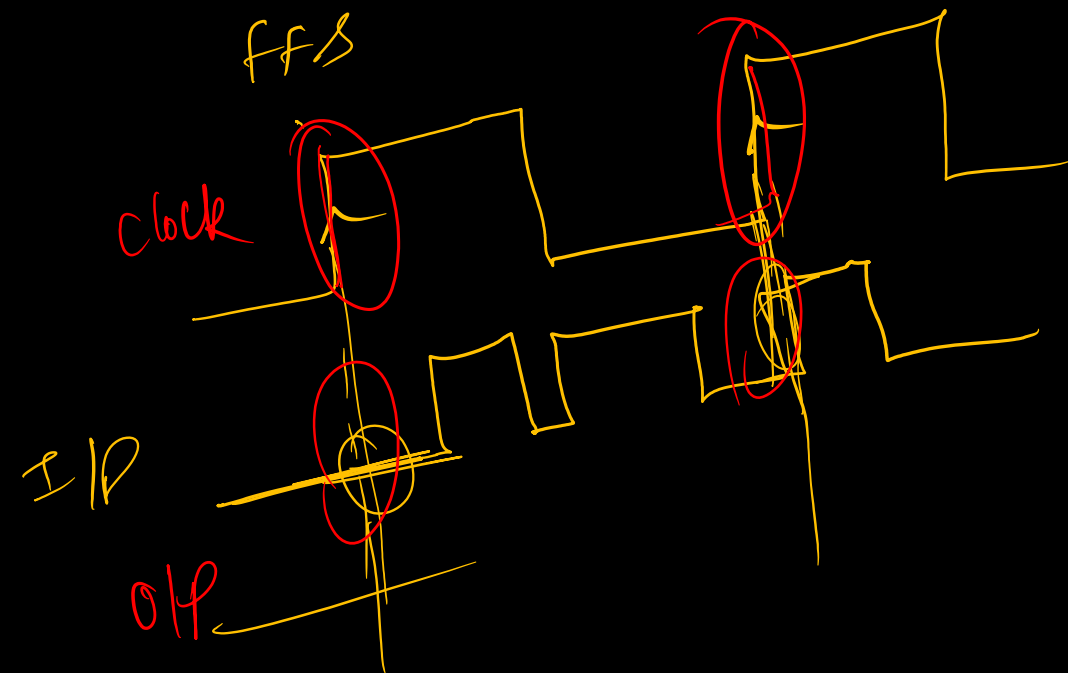
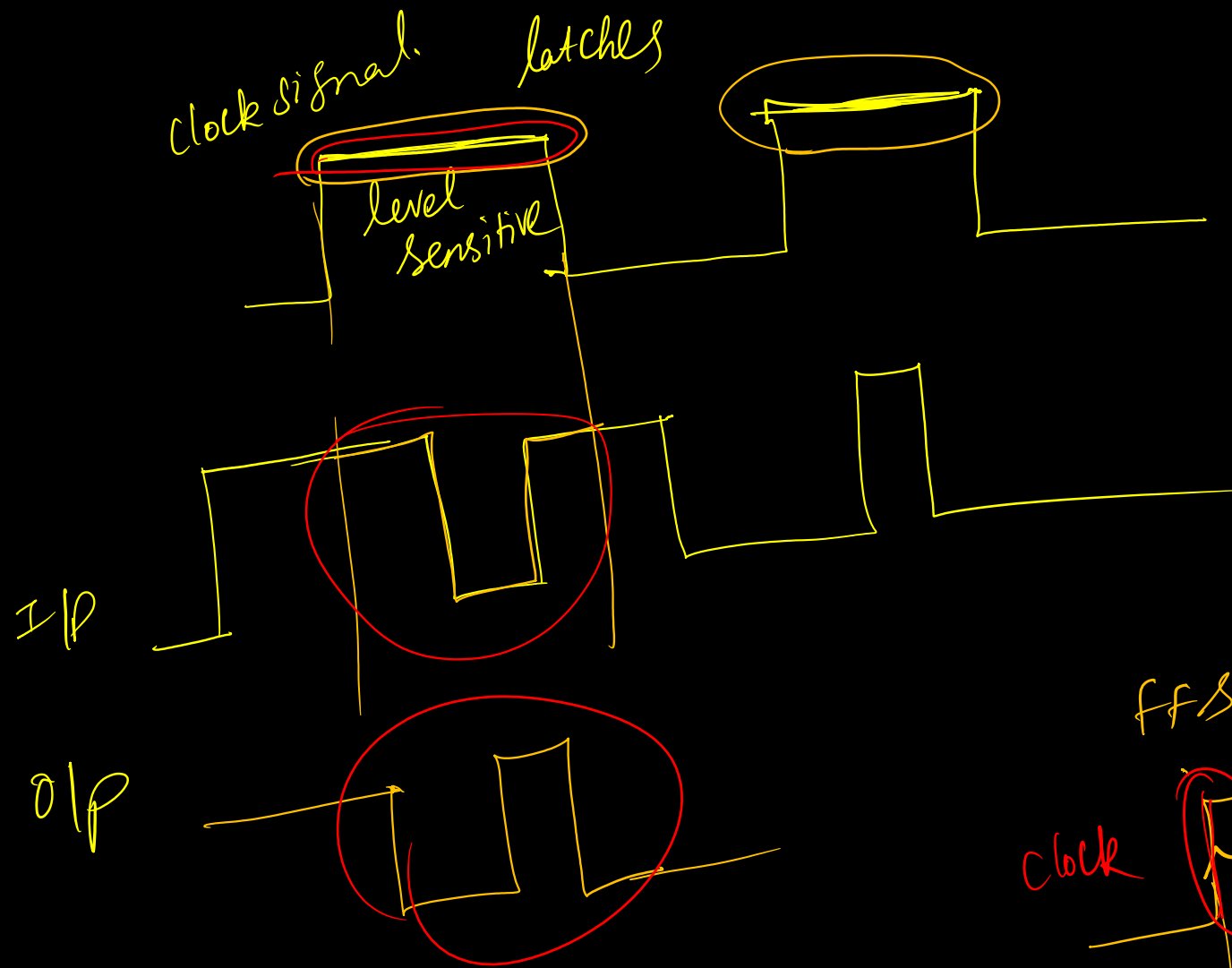


Flip-flops are circuits where the output follows input only during the clock transitions (**rising edge/falling edge**)

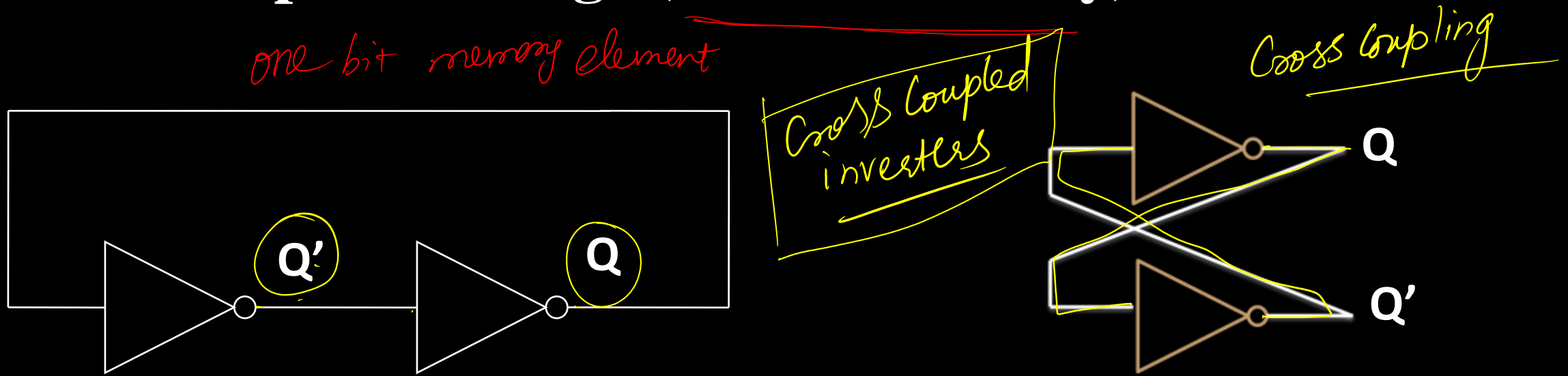
FFs are controlled latches



Latches are the basic circuits from which flip-flops are constructed (building blocks of FFs)



Basic Concept of Storage (one bit memory)

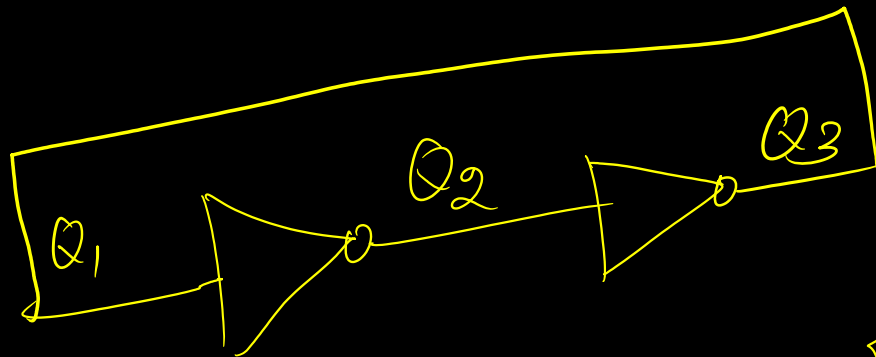


- The circuit remembers Q (never changes as long as powered on) as well as Q' .
- We can read Q by checking the output.

A latch is a simple digital circuit where the output can be set to either logic 1 or logic 0 by an input signal.

The circuit then remains in/“remembers” this state even after the input is removed.

This is a memory circuit that can “remember” a single binary digit (bit). *‘0’ or ‘1’*



Remove f/b

Connect Q_1 to ground

Connect Q_1 to V_{CC}

