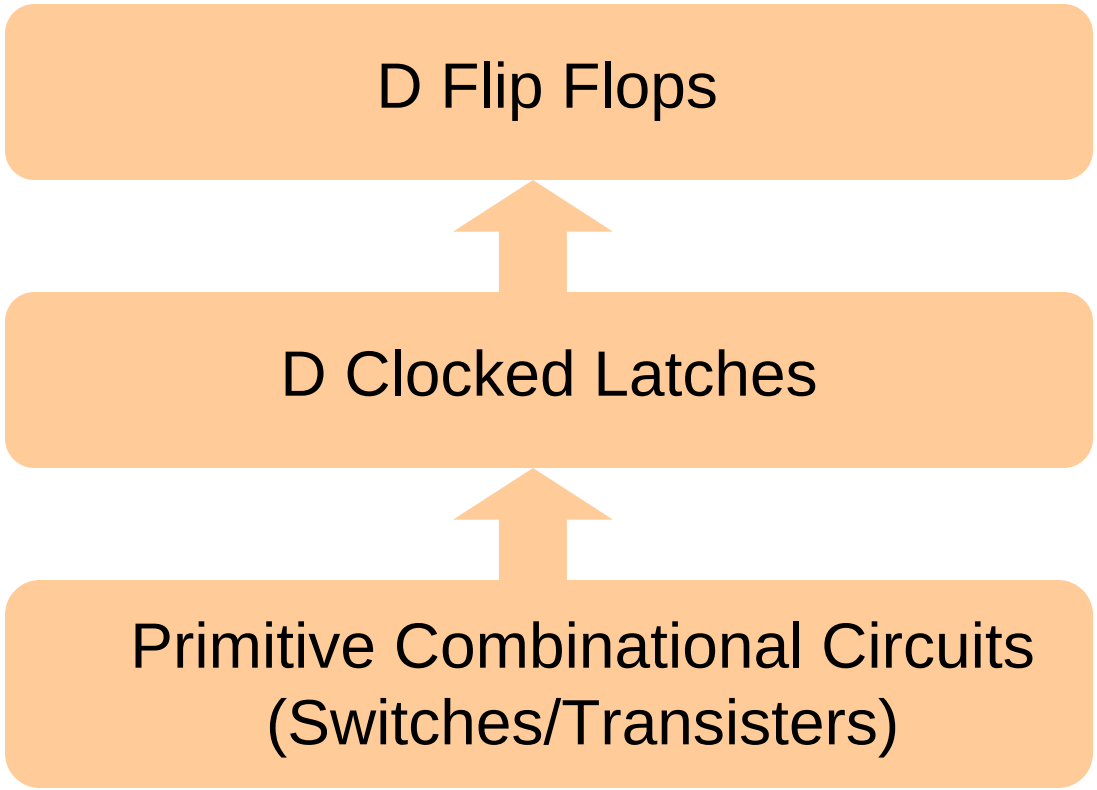
Building D Flip Flops

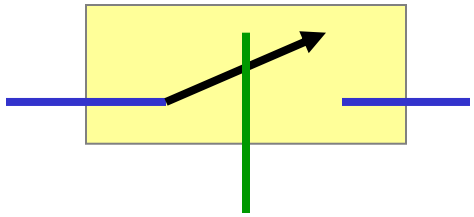
- Combinational Circuit Components
  - Switches
  - Voltage inverters
- D Clocked Latch
  - Feedback to store bits
- D Flip Flop
  - Two D clocked latches

Building D Flip Flops

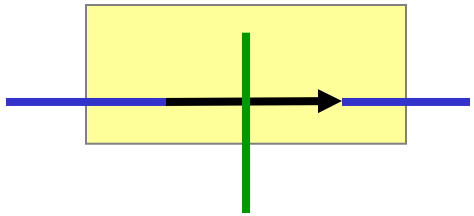


Combinational Circuit Components

Normally Open Switch

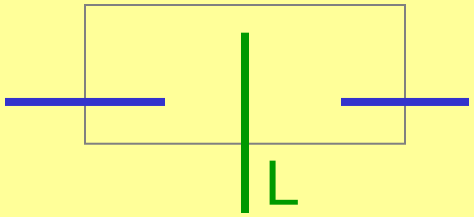


Normally Closed Switch

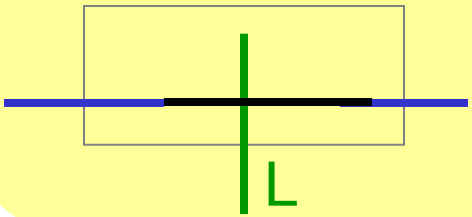


Control = L

open

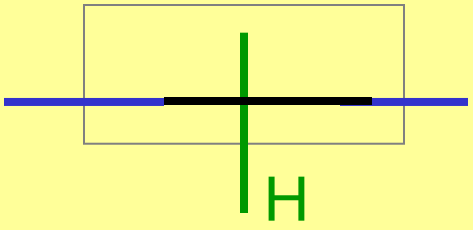


closed

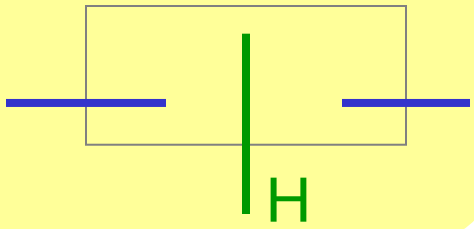


Control = H

closed

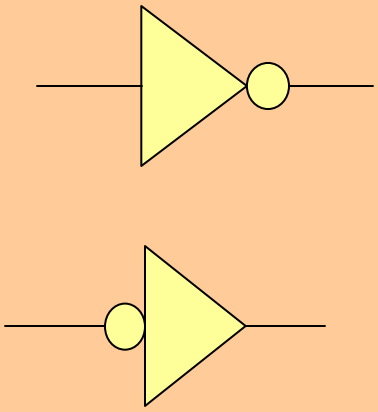


open

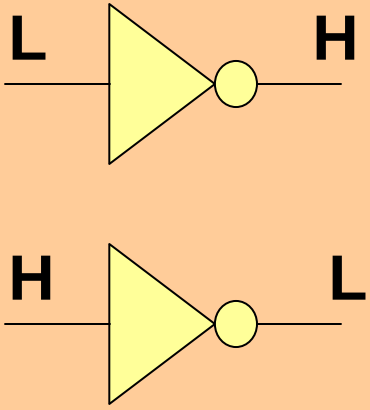


Combinational Circuit Components

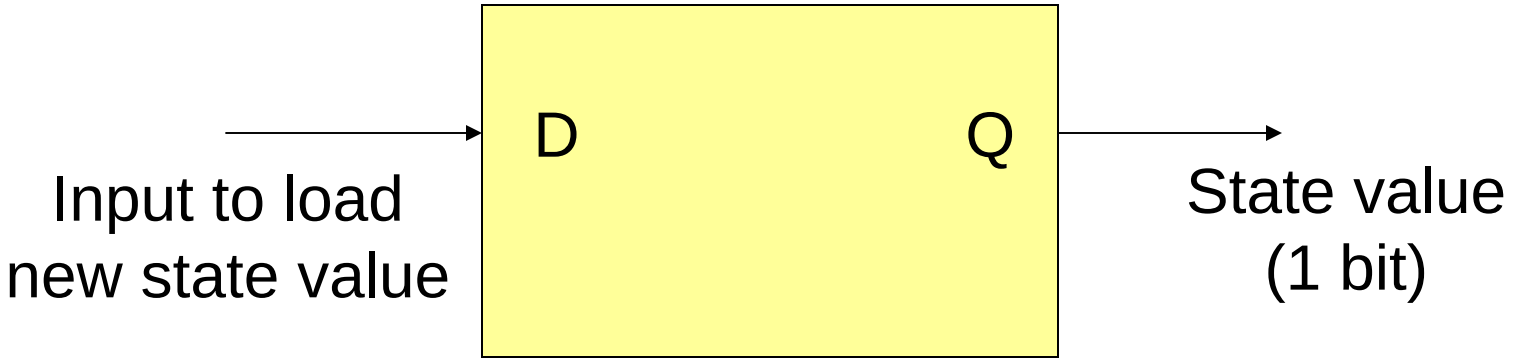
Voltage Inverters
(2 symbols)



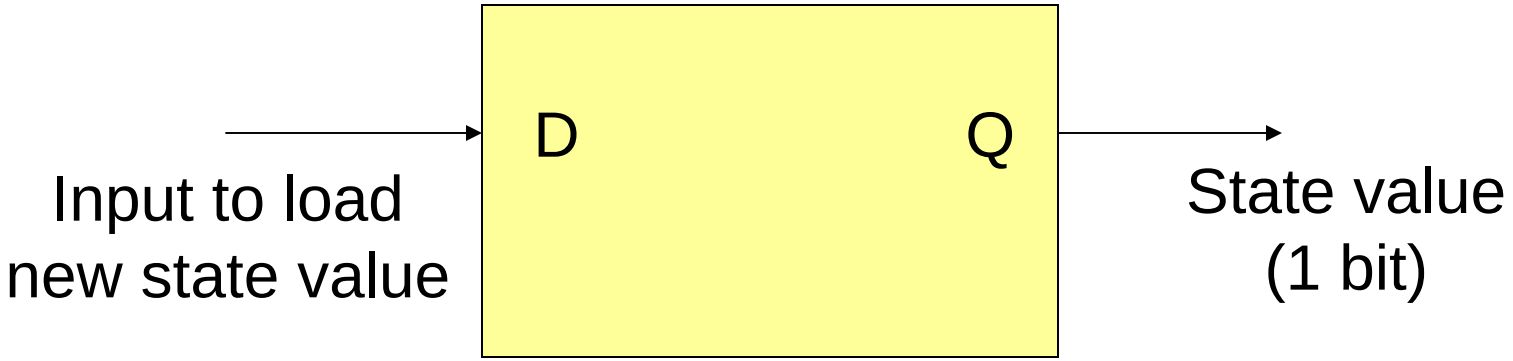
Active
Device



A Simple 1-Bit Memory



A Simple 1-Bit Memory



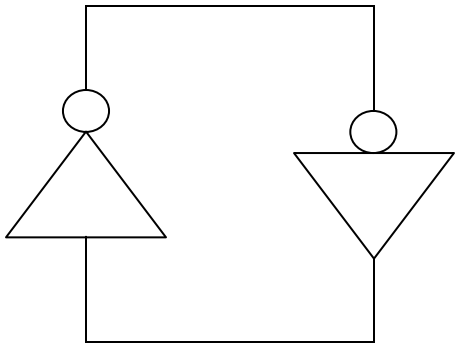
Two configurations:

Hold (store) = hold onto the state value

Load = load a new state value

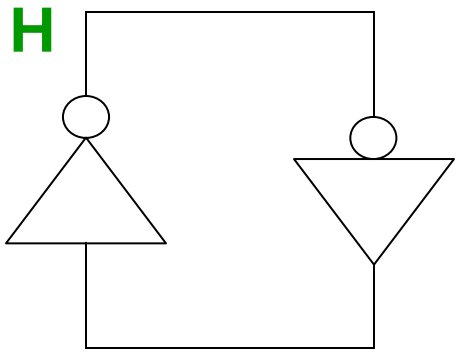
Holding (Storing) With Voltage Inverters

Devices drive each other



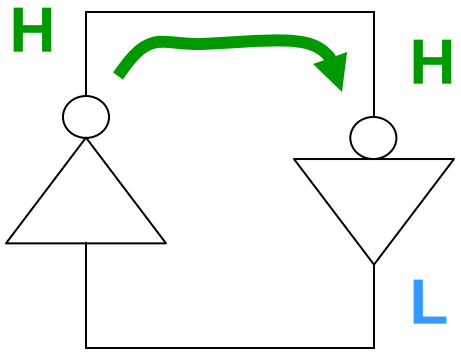
Holding (Storing) With Voltage Inverters

Devices drive each other



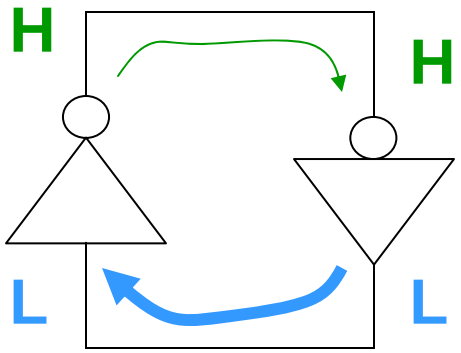
Holding (Storing) With Voltage Inverters

Devices drive each other



Holding (Storing) With Voltage Inverters

Devices drive each other



Holding (Storing) With Voltage Inverters

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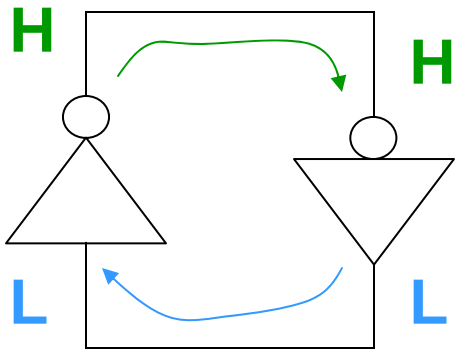
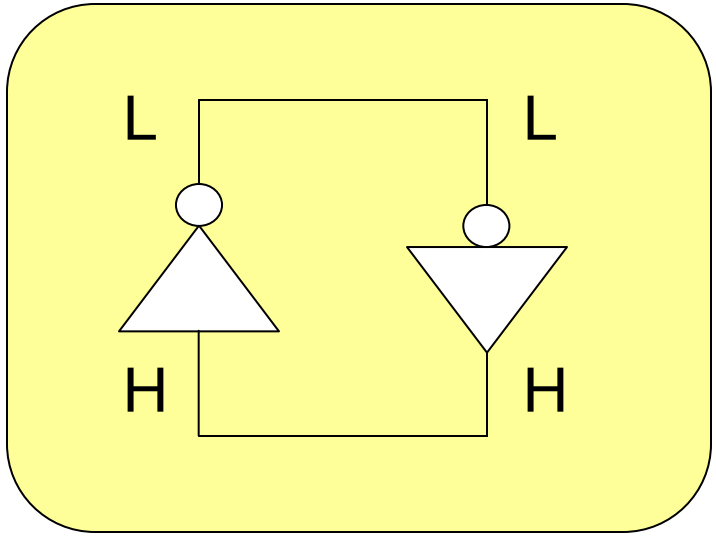
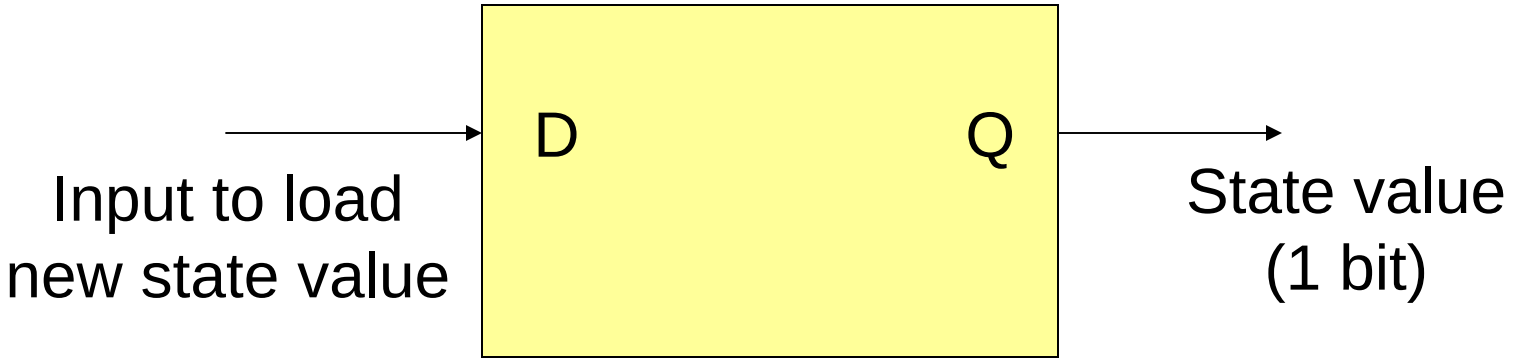




Simple Memory: Two Configurations

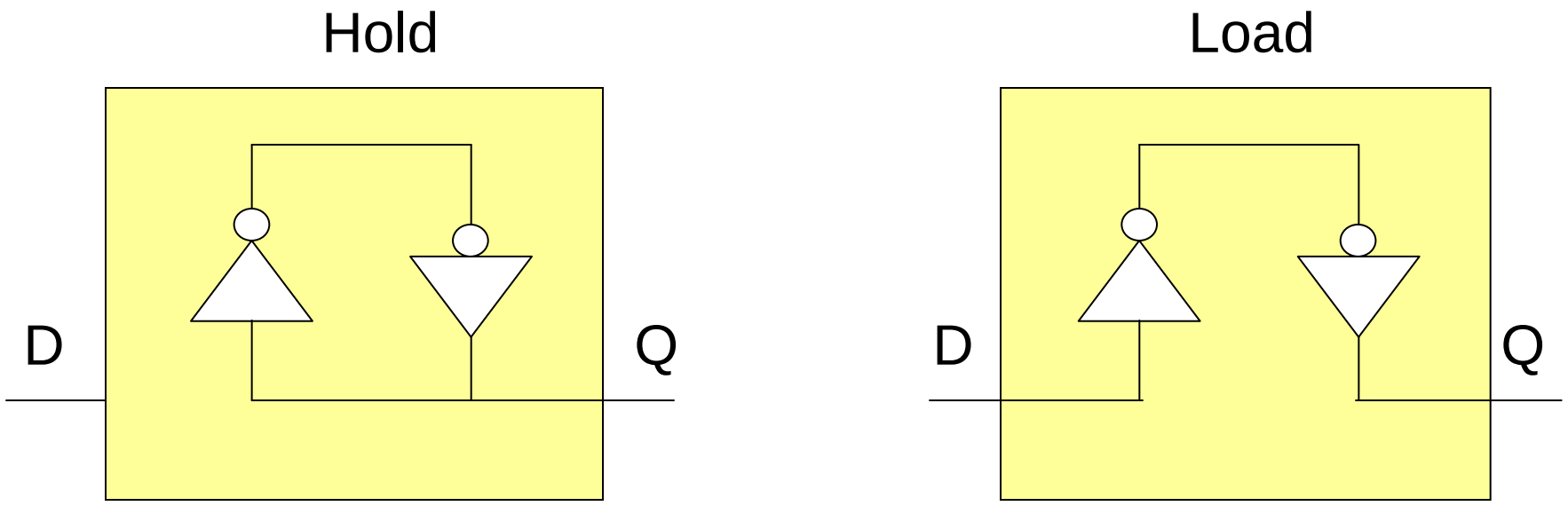


Two configurations:

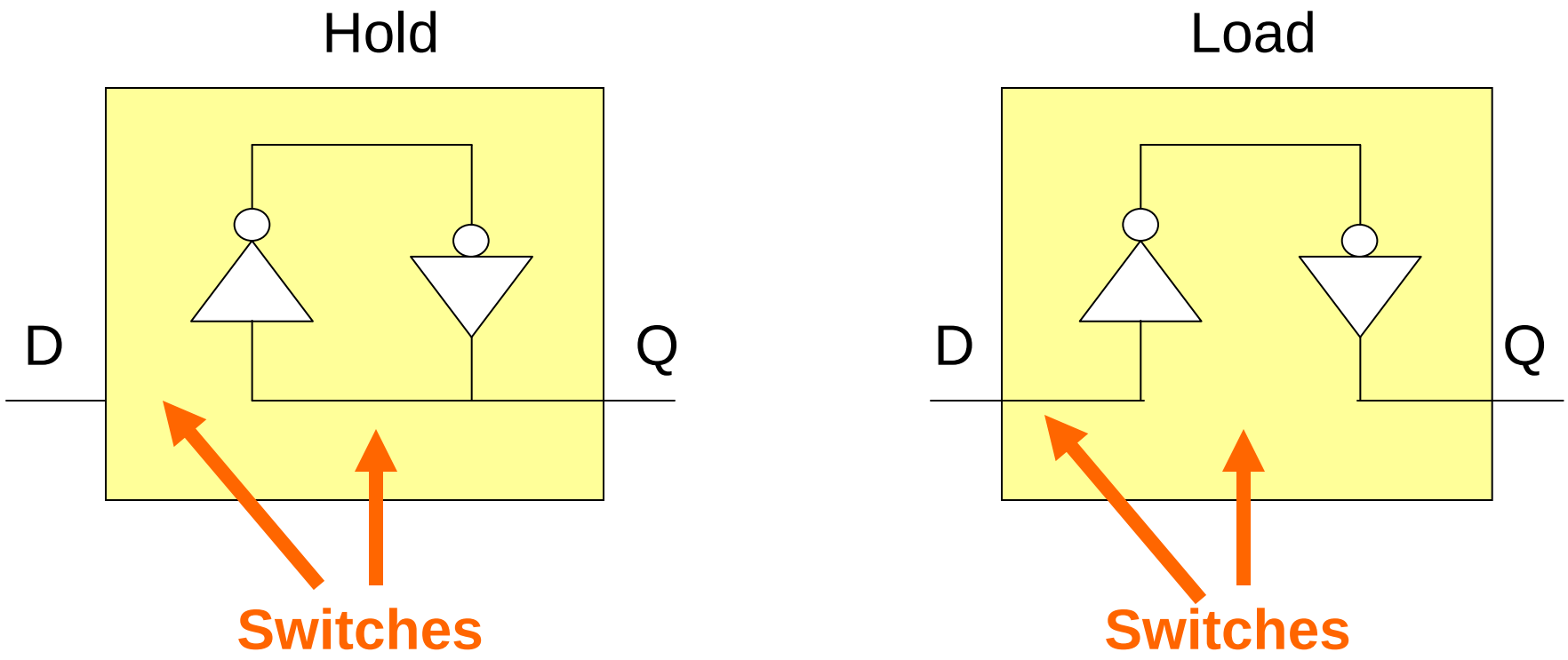
Hold (store) = hold onto the state value

Load = load a new state value

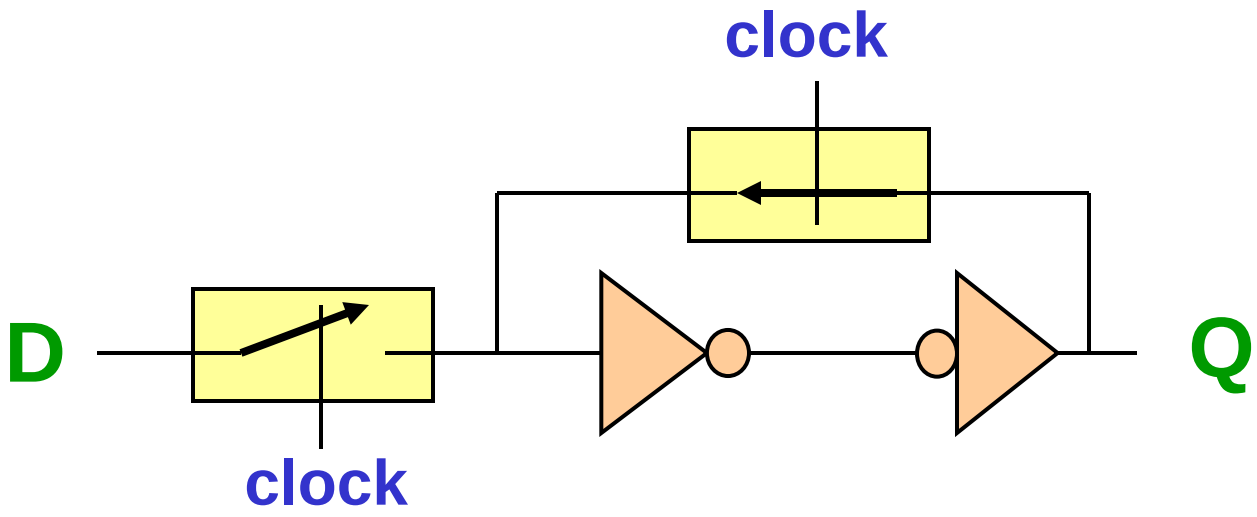
Simple Memory: Two Configurations



Simple Memory: Two Configurations



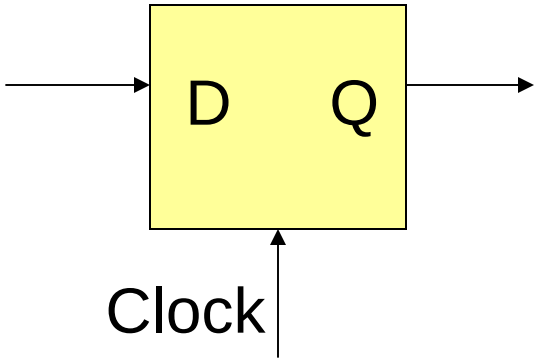
D Clocked Latch

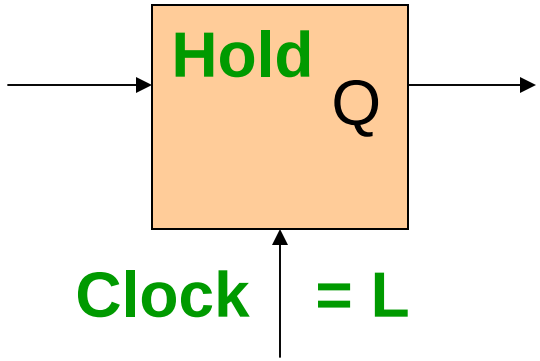


clock = L : Hold

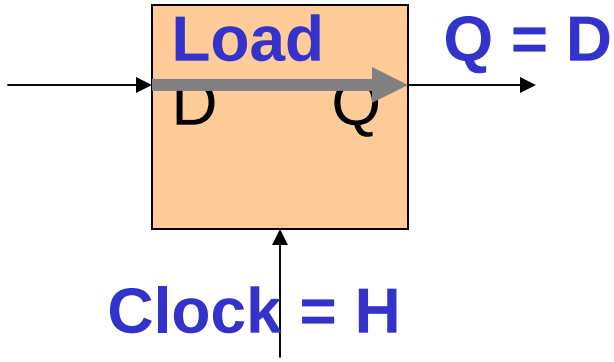
clock = H : Load

D Clocked Latch



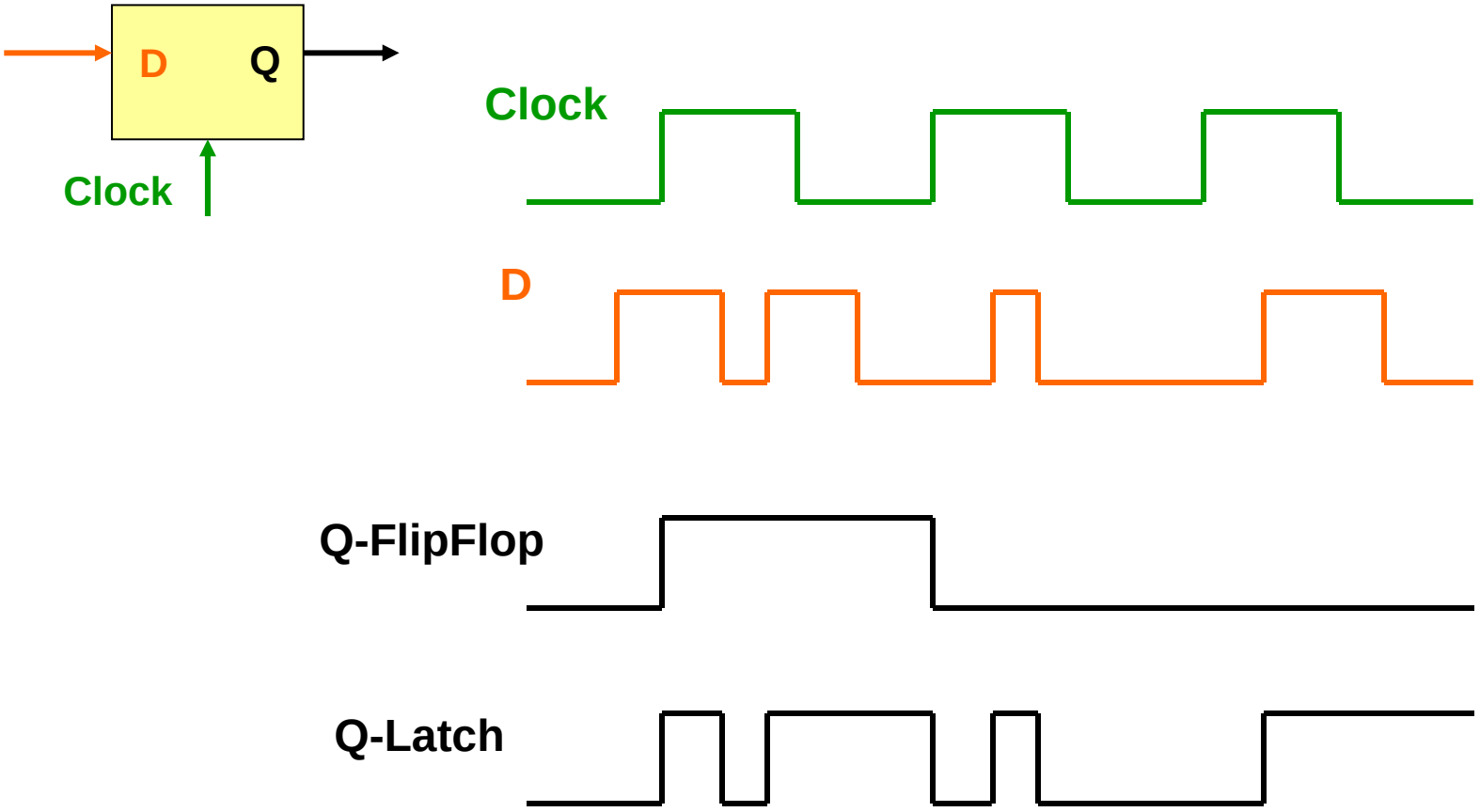


It similar to a D flip flop but it reacts to the clock differently

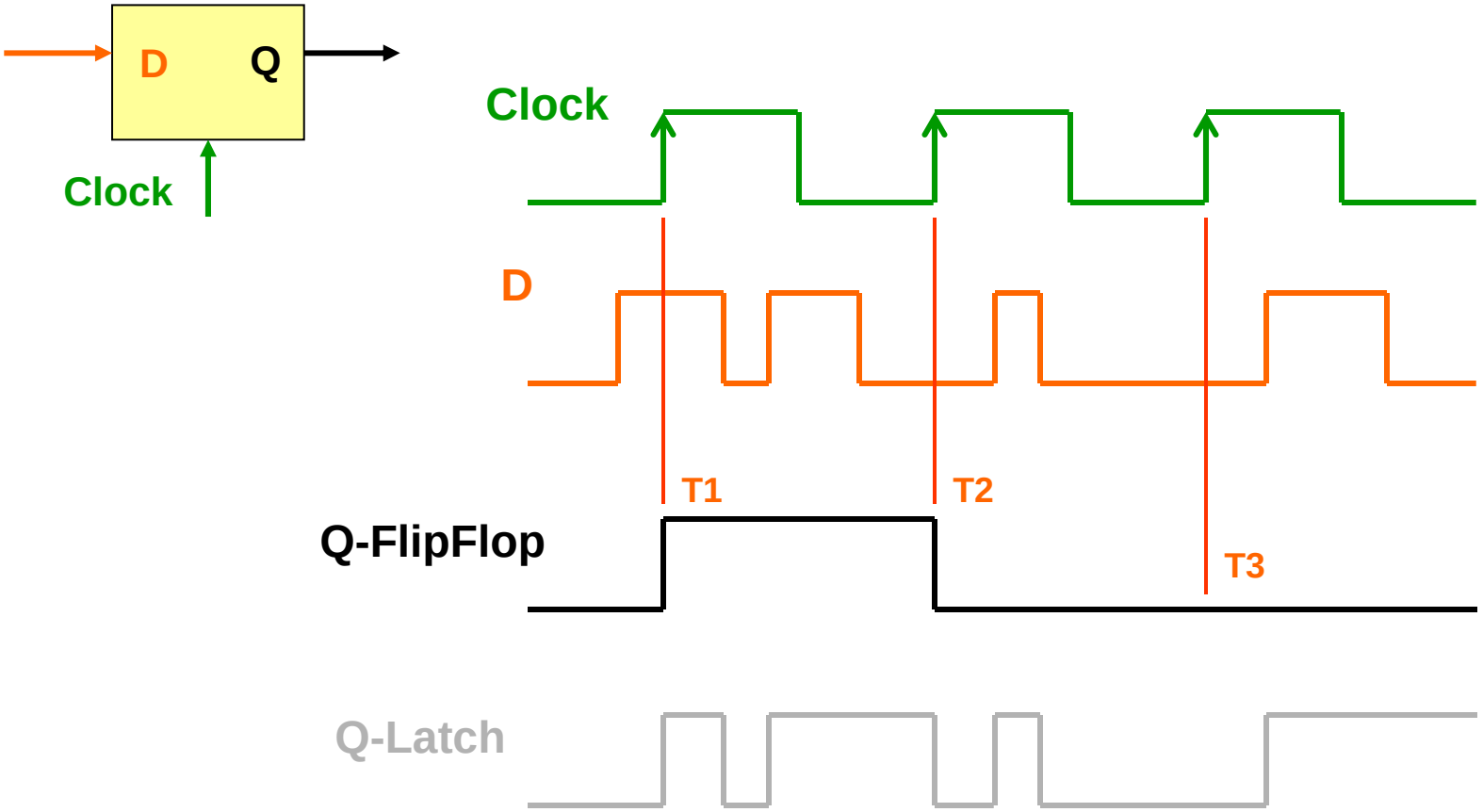


It's "transparent"

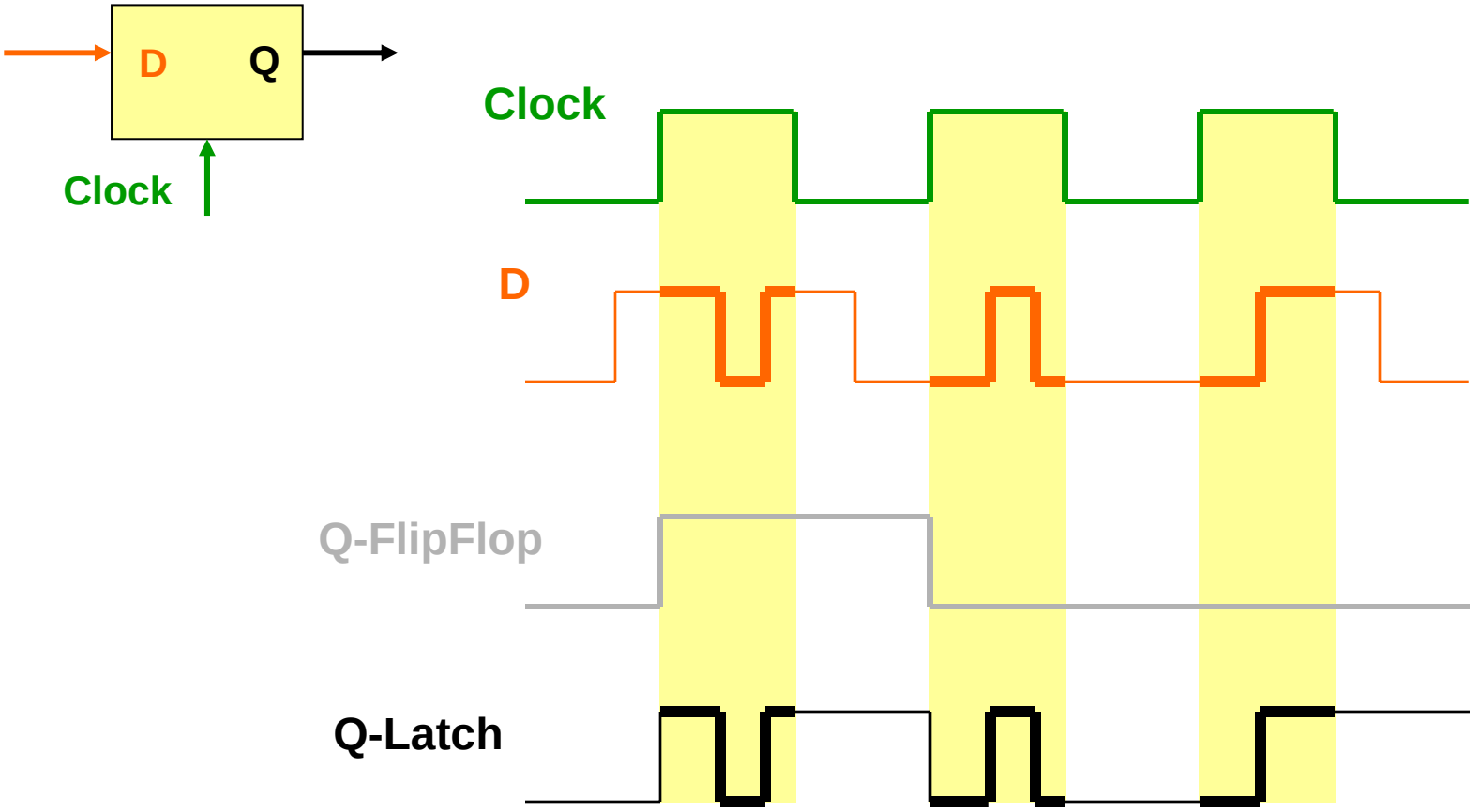
Comparing Flip Flop and Latch



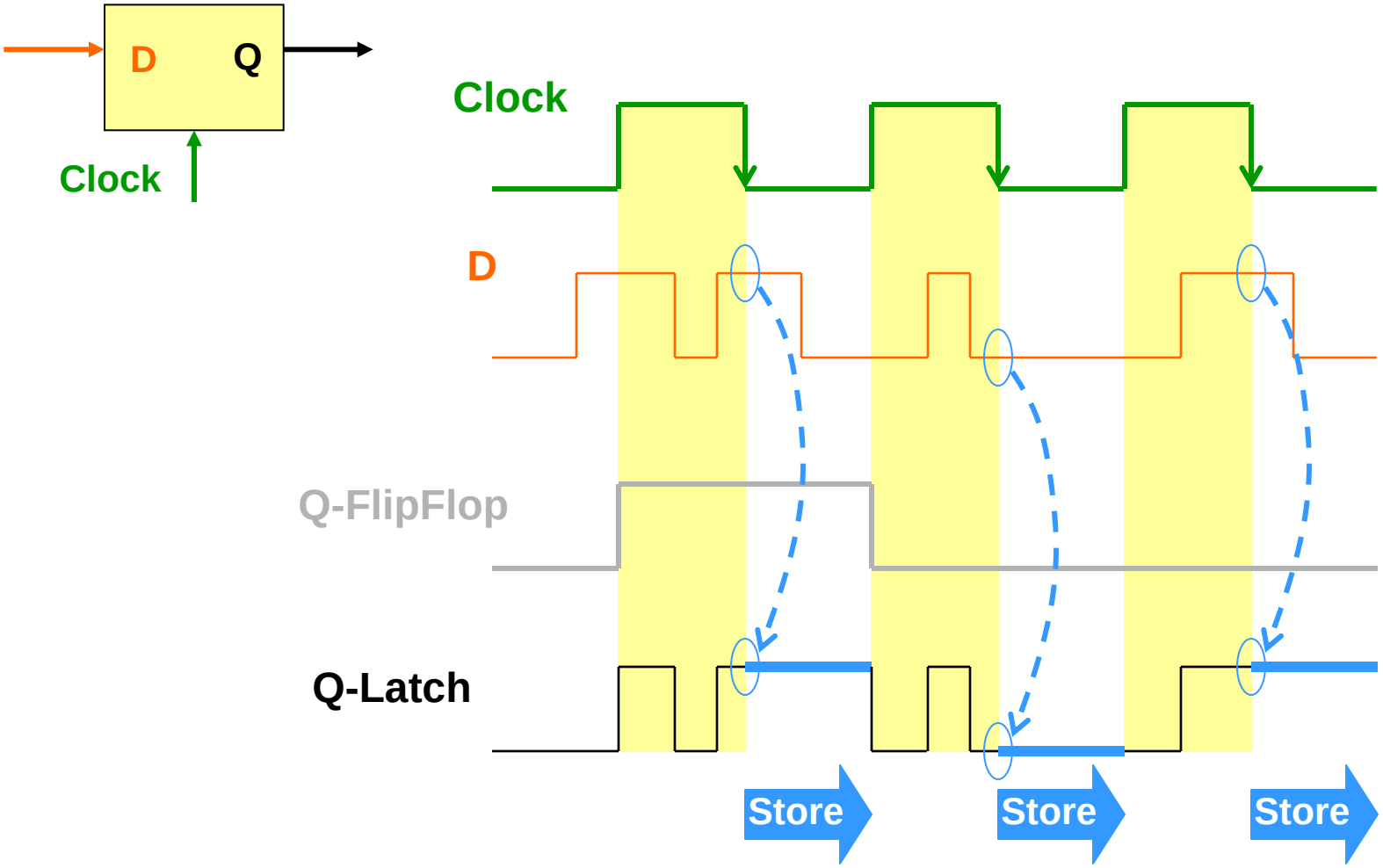
Comparing Flip Flop and Latch



Comparing Flip Flop and Latch



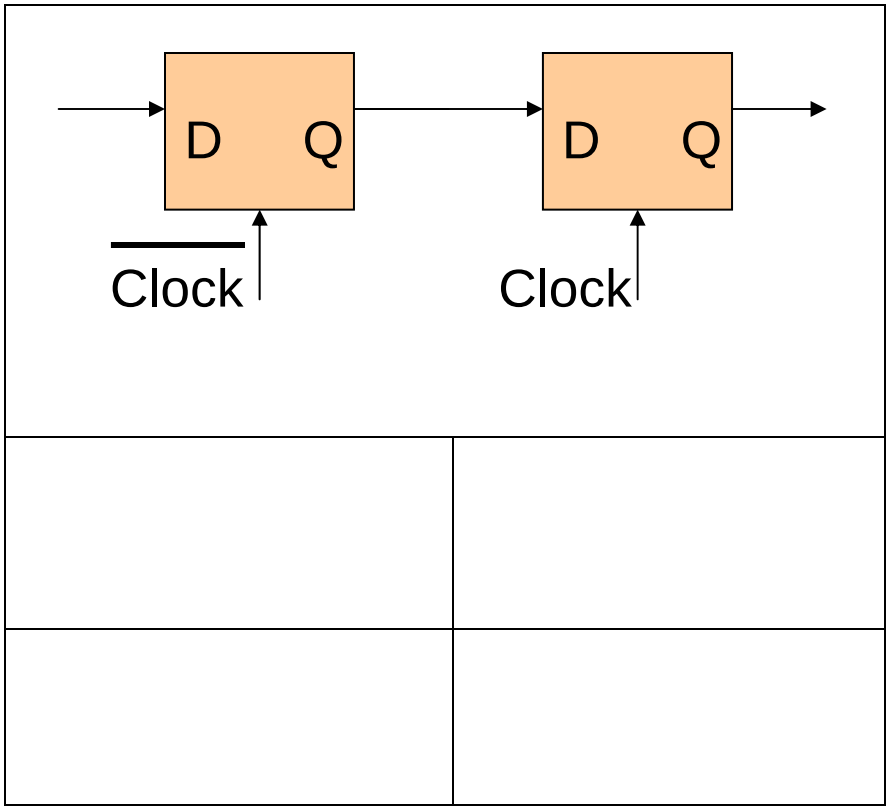
Comparing Flip Flop and Latch



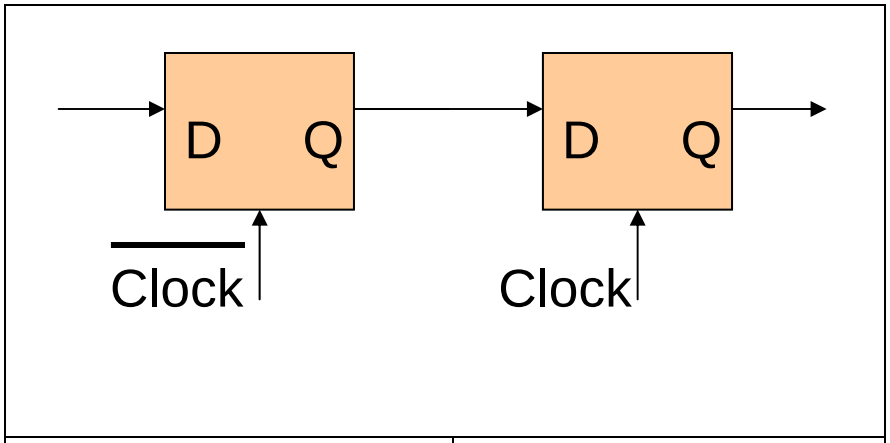
D Flip Flop vs. D Clocked Latch

- D flip flop
  - Triggered on positive edge of clock
  - Output Q (and state) changes only at a *time instant*
- D clocked latch
  - Output Q changes (with D) while clock is H
  - Output Q changes during a *window of time*
  - Trickier to use since lots of changes can happen during a time duration
    - Flip flops are preferred to latches in designing circuits
    - Latches are used in memory circuits, e.g., RAM

D Flip Flop

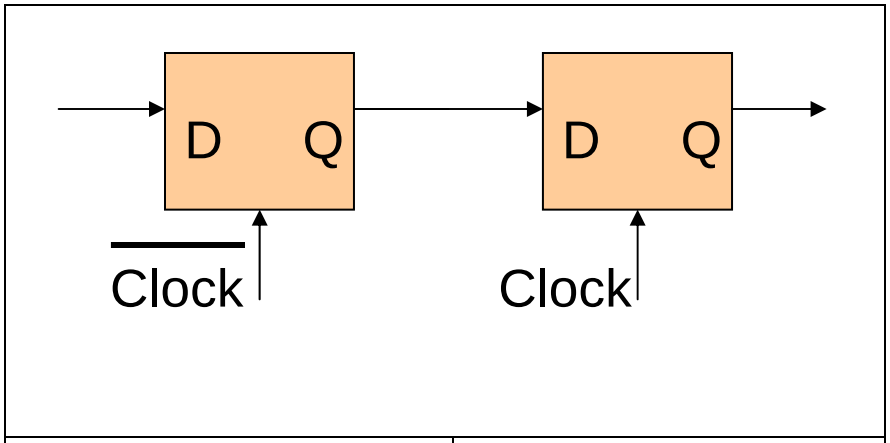


D Flip Flop



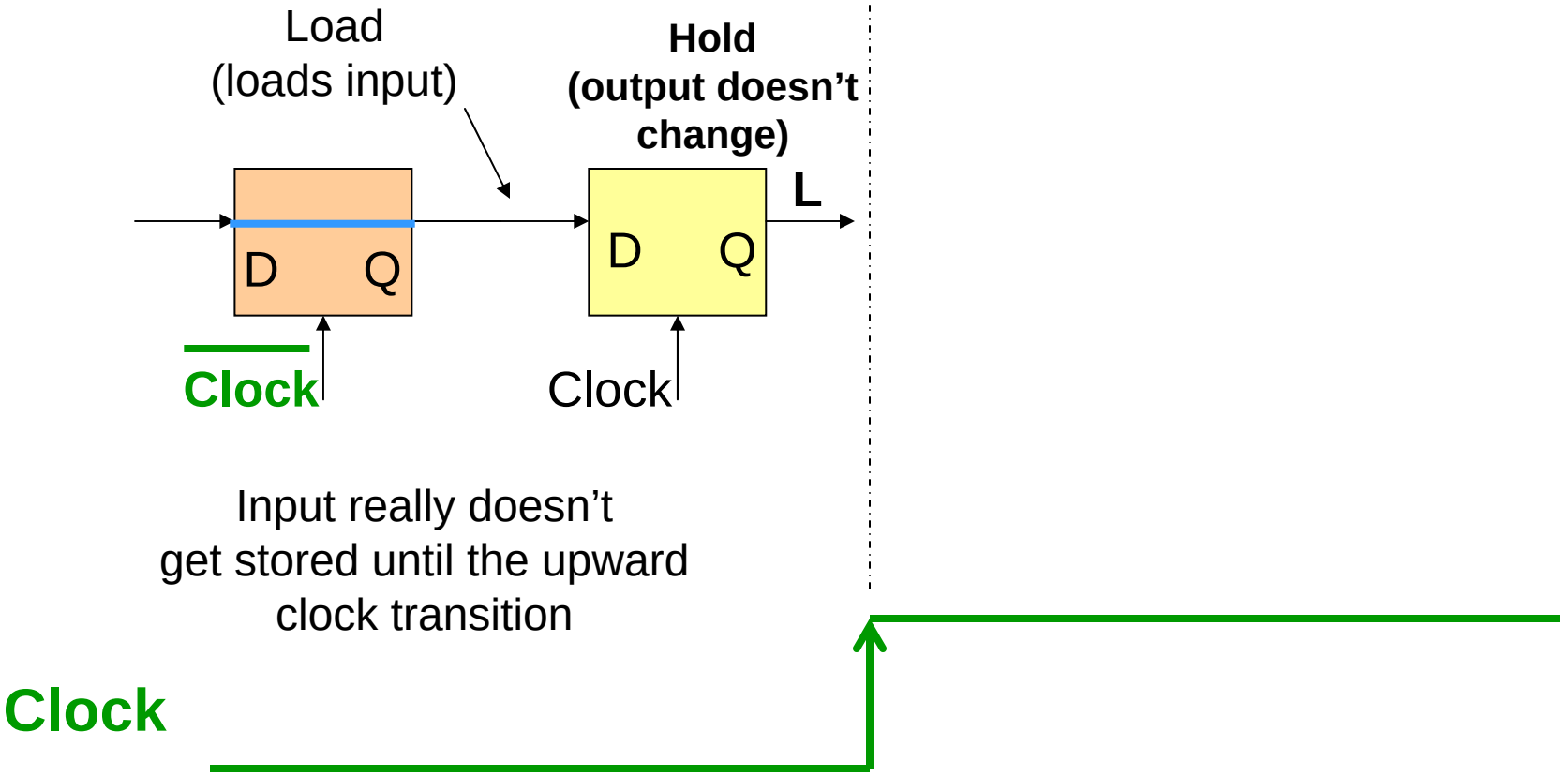
Clock = L	Load D → Q	Hold

D Flip Flop

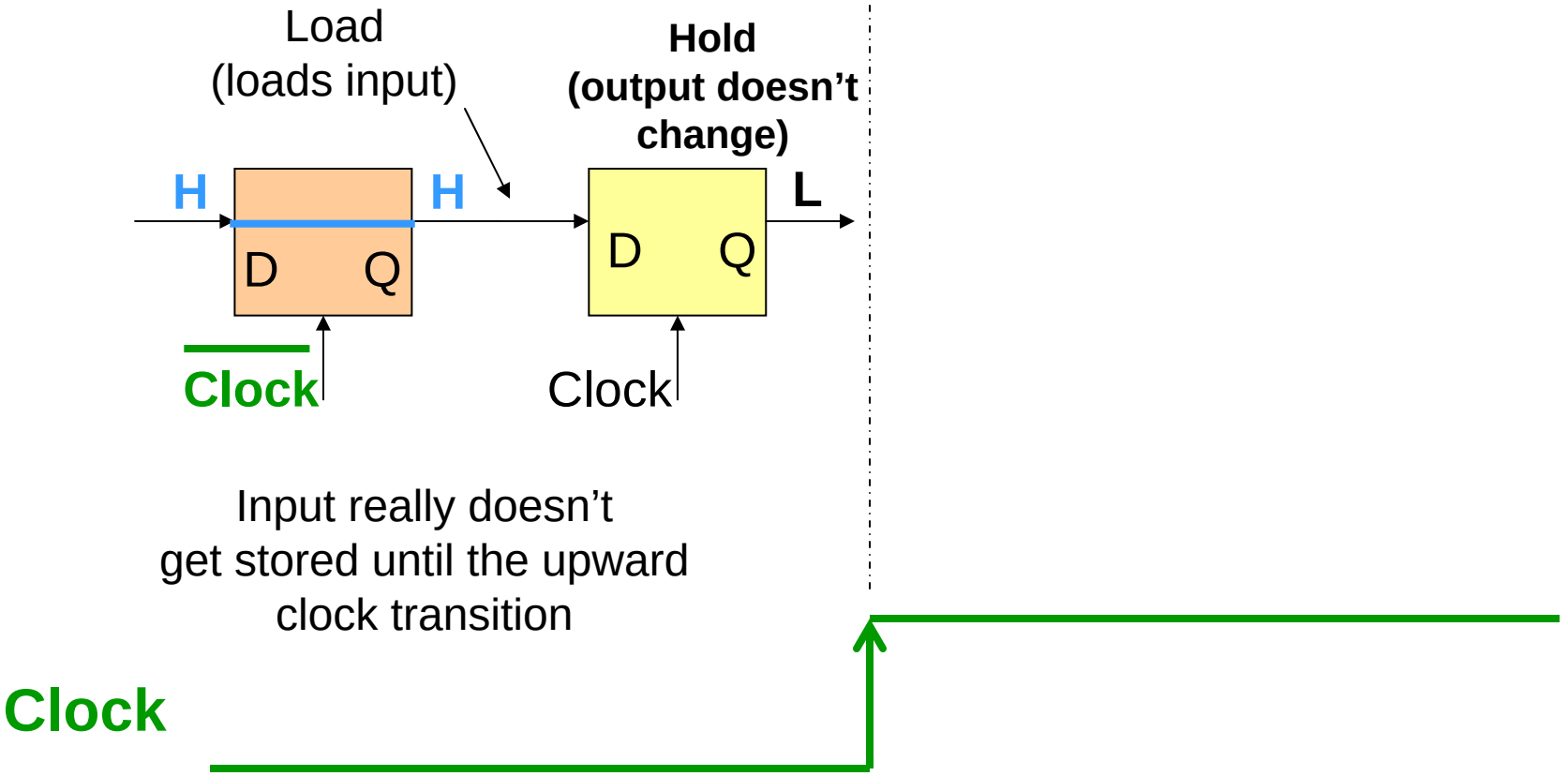


Clock = L	Load D → Q	Hold
Clock = H	Hold	Load D → Q

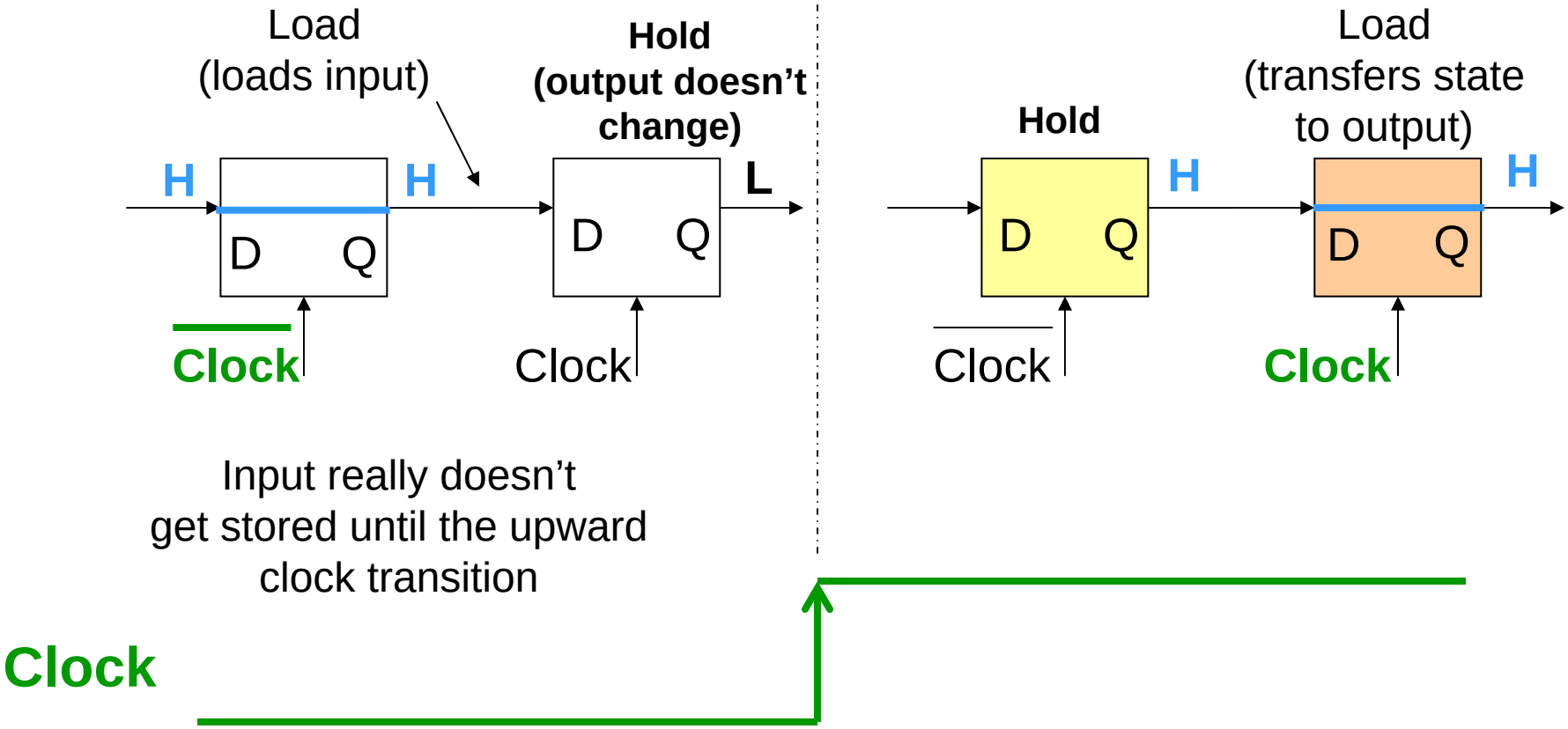
D Flip Flop


Load
(loads input)
Hold
(output doesn't
change)
L
D
Q
D
Q
Clock
Clock
Input really doesn't
get stored until the upward
clock transition
Clock

D Flip Flop


Load
(loads input)
Hold
(output doesn't
change)
H
H
L
D
Q
D
Q
Clock
Clock
Input really doesn't
get stored until the upward
clock transition
Clock

D Flip Flop


Load
(loads input)
Hold
(output doesn't
change)
Load
(transfers state
to output)
Hold
H
H
L
H
H
D
Q
D
Q
D
Q
D
Q
Clock
Clock
Clock
Clock
Input really doesn't
get stored until the upward
clock transition
Clock

Summary

- Combinational circuit components
  - switches and voltage inverters
- D clocked latch
  - Built from switches and voltage inverters
  - 2 configurations: load and hold
- D flip flop
  - Built from two D latches in series