Digital Design and Computer Organization

Latches, Flip-flops - 1

Reetinder Sidhu

Department of Computer Science and Engineering

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Course Outline

- Digital Design
  - Combinational logic design
  - Sequential logic design
    - ★ **Latches, Flip-flops - 1**
- Computer Organization
  - Architecture (microprocessor instruction set)
  - Microarchitecure (microprocessor operation)

Concepts covered

- Memory Elements
- SR Latch

Latches, Flip-flops - 1

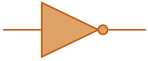
How does Sequential Logic differ from Combinational Logic?

- Sequential logic circuits contain logic elements that can “remember”
  - Such a logic circuit, called a **memory** or **storage** element, remembers one or more bits of data which forms the **state** of the logic circuit
- Recall that combinational logic circuits implement Boolean functions
  - Functions cannot “remember” (output is a function of inputs)
- Also recall that in combinational logic circuits, an output of a logic circuit cannot be connected back to one of its inputs
  - Can breaking above restriction yield storage elements?

LATCHES, FLIP-FLOPS - 1

How to Implement Memory?

- The inverter is essentially the simplest logic gate
- What happens when we connect its output to input, forming a loop?



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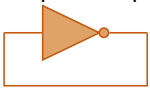

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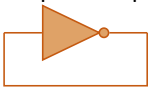

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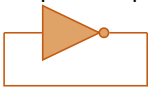

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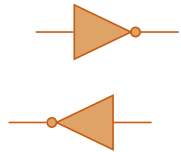

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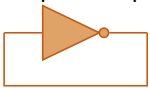

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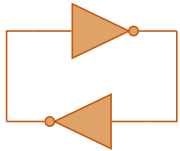

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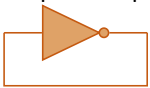

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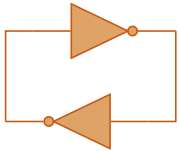

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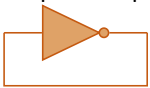

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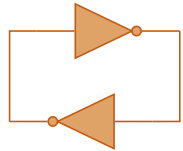

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- A bit can have one of two different values

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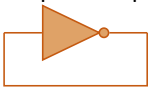

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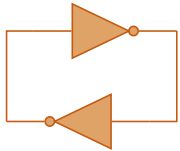

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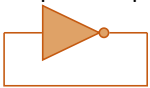

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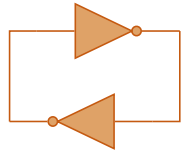


- Two inverter loop can be in one of two stable states
- A bit can have one of two different values
- Thus a two inverter loop can store (“remember”) a single bit
- But how to change the bit stored / stable state?

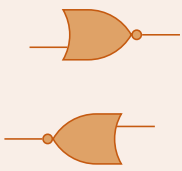
Latches, Flip-flops - 1

SR Latch

SR Latch

SR Latch Operation

- SR latch logic diagram:



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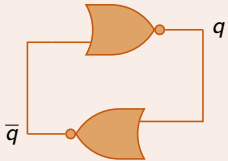

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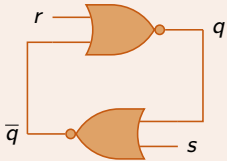

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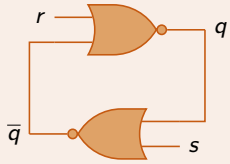

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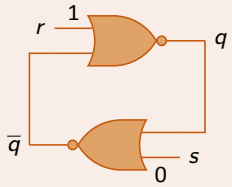

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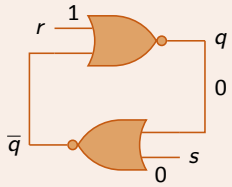

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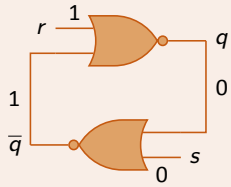

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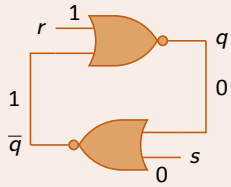

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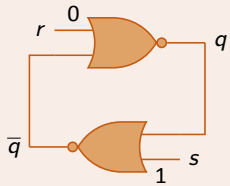

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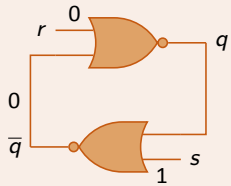

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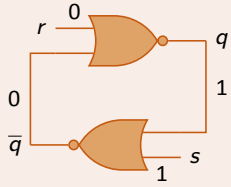

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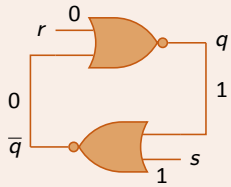

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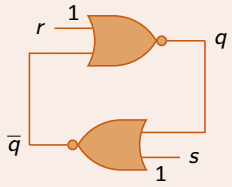

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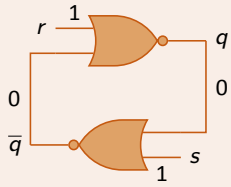

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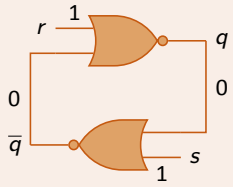

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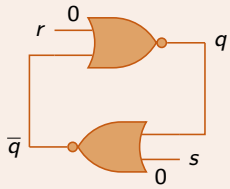

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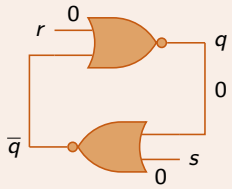

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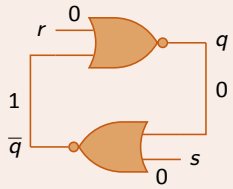

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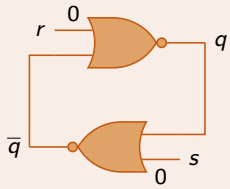

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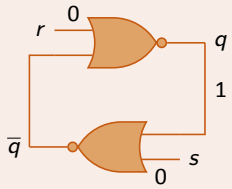

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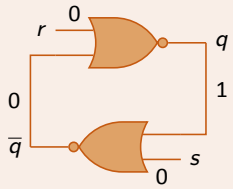

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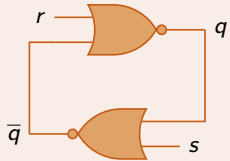

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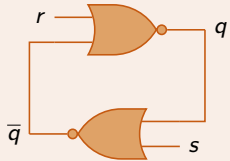

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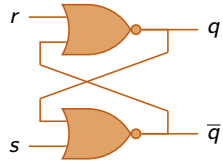

LATCHES, FLIP-FLOPS - 1

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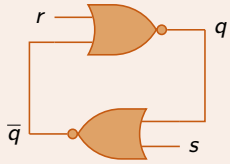

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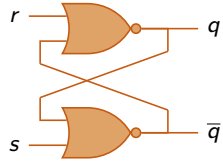
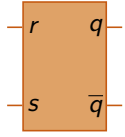
1	1	0	0

- SR latch conventional logic diagram:



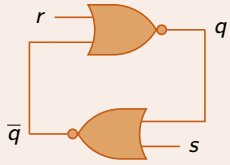
- SR latch symbol:



SR Latch

SR Latch Operation

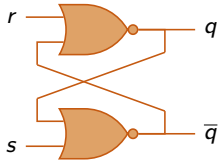
- SR latch logic diagram:



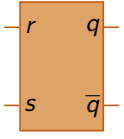
- SR latch truth table:

s	r	q	$\overline{q}$
0	0	q_{prev}	$\overline{q}_{prev}$
0	1	0	1
1	0	1	0
1	1	0	0

- SR latch conventional logic diagram:



- SR latch symbol:

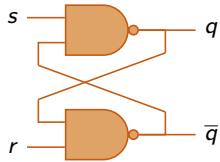


- In this manner a single bit (0 or 1) can be stored in an SR latch
  - Bit stored when $r = 0,\ s = 1$ or $r = 1,\ s = 0$
  - Bit remembered when $r = 0,\ s = 0$

Think About It

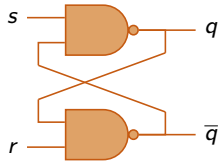
Latches, Flip-flops - 1

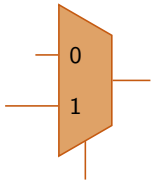
Think About It



Latches, Flip-flops - 1

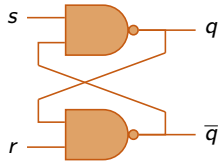
Think About It

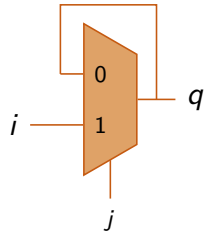




Latches, Flip-flops - 1

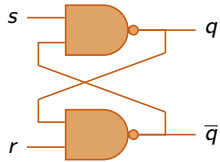
Think About It

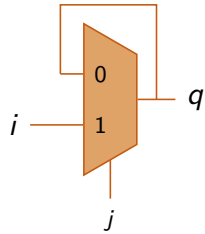




Latches, Flip-flops - 1

Think About It





- Write the truth tables for the above logic circuits