Combinational Logic

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Combinational Logic Circuit

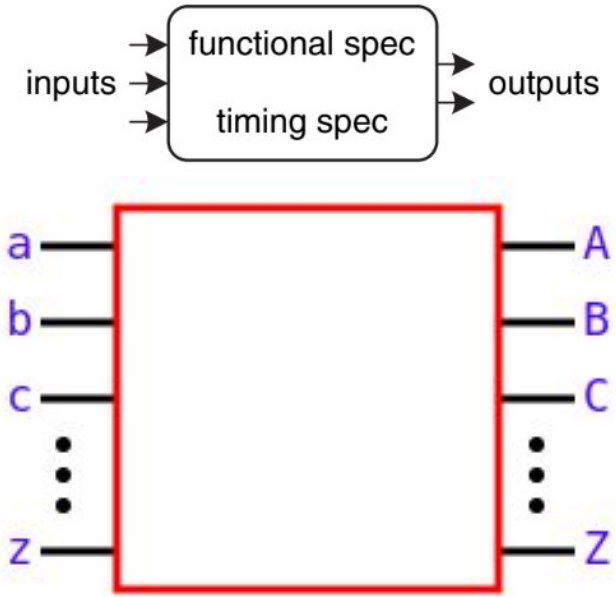
A digital logic circuit is a combinational logic circuit if the values of the outputs depend only on the current values of the inputs. Combinational circuits have no memory.

Combinational and Sequential Circuits

- Combinational circuits
  - Output depends only on the current input values.
  - Memoryless.
- Sequential circuits
  - Output depends both on the current and past.
  - Has some memory.
- Important to differentiate

Combinational Logic Circuit

- One or more input terminals (ports)
- One or more output terminals
- A functional description
  - In terms of current input.
  - Described by a truth table.
  - Boolean equation.
- A timing description (maximum delay)
  - Lower and upper bounds expected.
  - From input to the output.
- Abstraction
- Black-box idea



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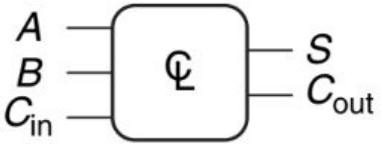
$$Y = F(A, B) = A + B$$

(a)

(b)



$$S = A \oplus B \oplus C_{in}$$

$$C_{out} = AB + AC_{in} + BC_{in}$$

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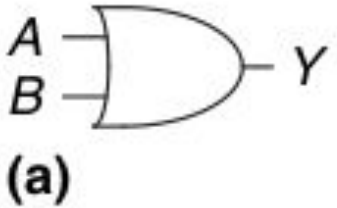
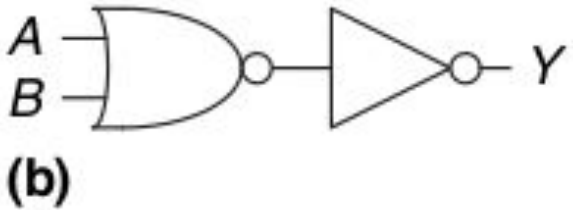
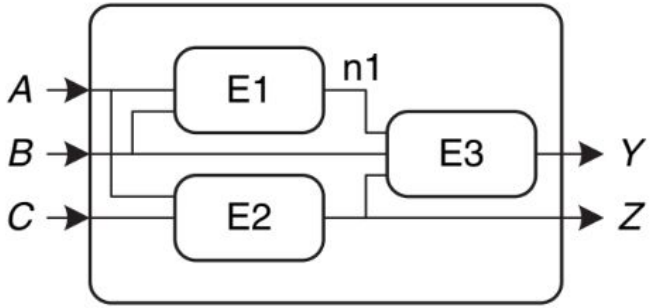
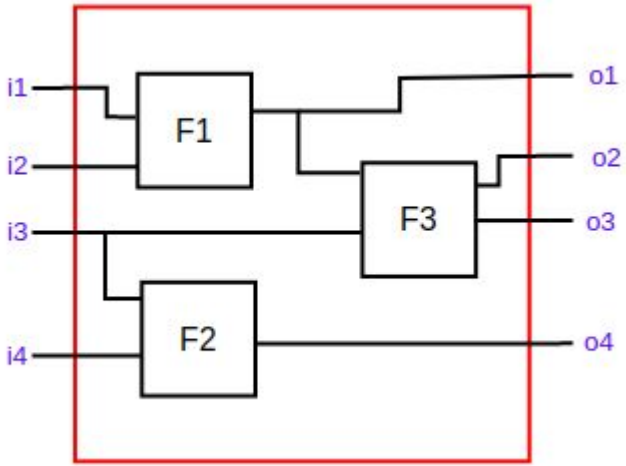




Combinational Logic Circuit

- Composed of smaller combinational circuits (sub-circuits)
- The larger circuit is combinational if the sub-circuits are combinational.
- Every sub-circuit must be combinational.
- A wire in the circuit (node)
  - Is controlled by the input;
  - or by the output other sub-circuits.
- No cyclic paths in the circuit (feedback)





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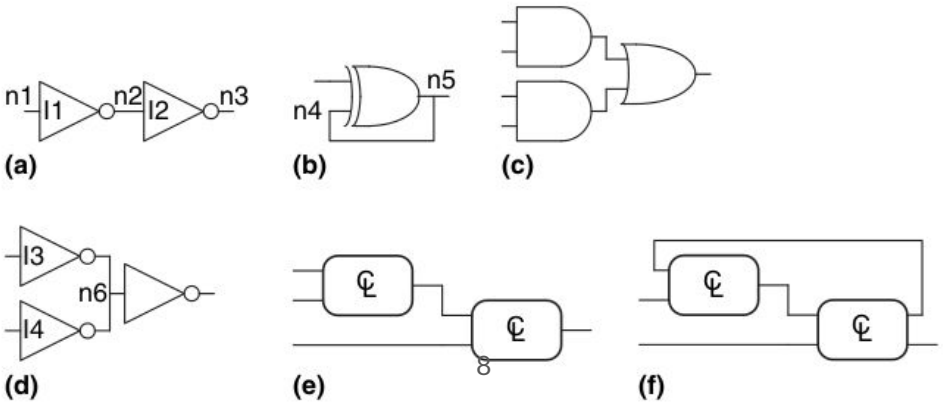

Example Combinational Circuits and Boolean Functions

- Variables (a, b, c, cin, ...) are the inputs
- Operators (“•”, “+”, “not”, …) are the gates
- Function (Y, g7, cout, ...) is the output
- The circuit is drawn by first using NOT gates to invert any input is complemented (i.e., have an over line). Then the operators are changed to their matching gate.

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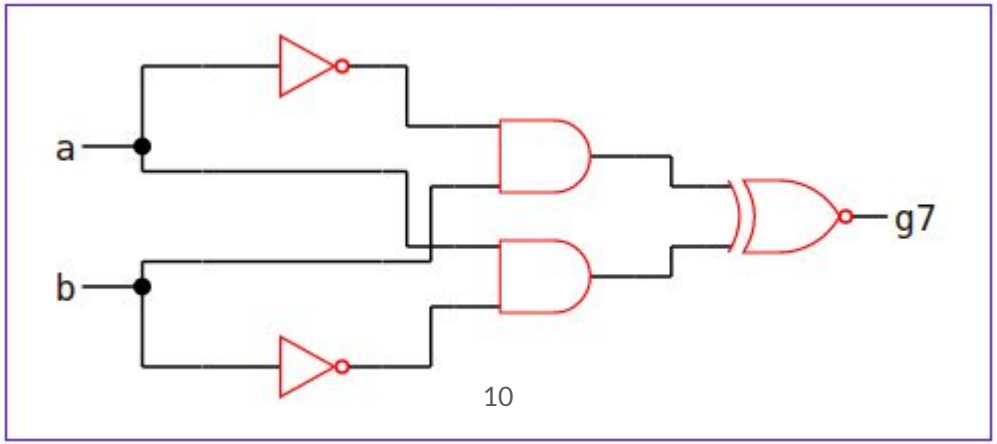

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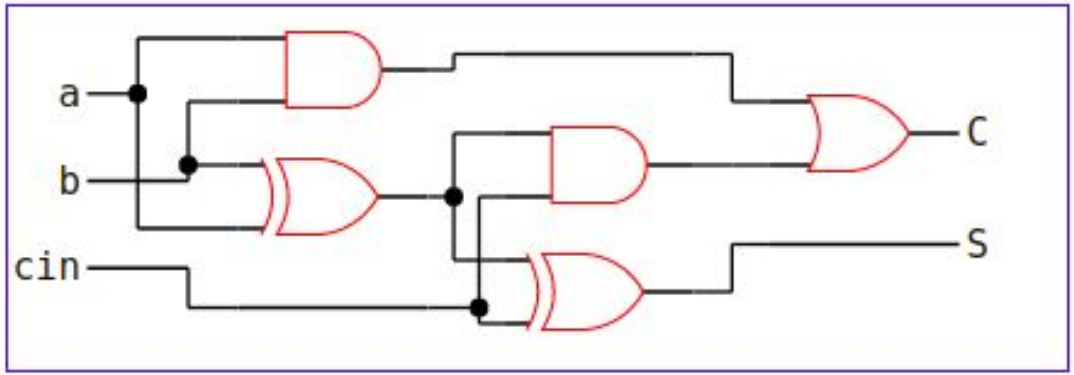
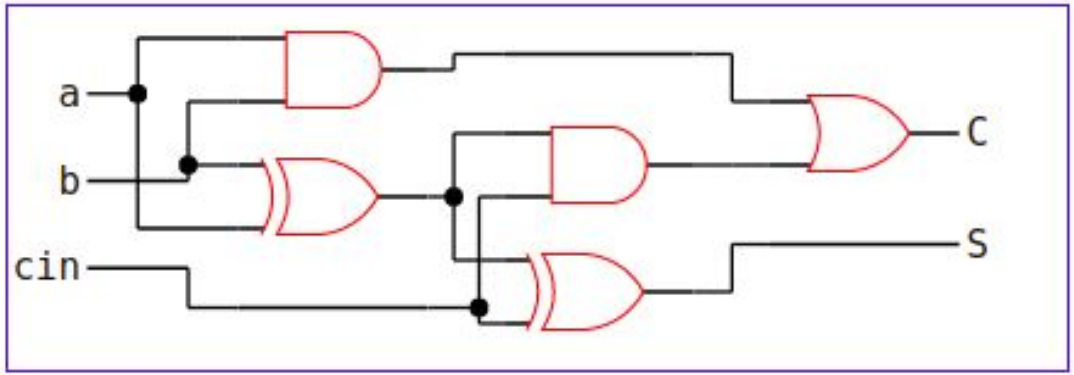


Example Combinational Circuits and Boolean Functions

$$C = (a \cdot b) + ((a \oplus b) \cdot cin)$$
$$S = ((a \oplus b) \oplus cin)$$



Questions?

- Next: Boolean algebra
- Rules and identities
- Simplification