

Chapter 9

PROBLEM FORMULATION AND DESIGN OF COMBINATIONAL CIRCUITS

Lesson 1

Combinational Circuit

Outline

- **Definition**
- Representation
- Seven Building Blocks
- Problem Formulation
- Specifications of each output

Definition

- A combinational circuit is a circuit made up by combining logic gates such that the required logic at the output(s) depends only on the input logic present condition, both completely specified by either a truth table or by a Boolean expression

Characteristics

- (i) An output(s) remains constant, as long input conditions do not require change in output(s),
- (ii) An output depends solely on the current input condition and not on any past input condition or past output condition,

Characteristics

- (iii) A combinational circuit has no feedback of the output from a stage to the input of either that stage or any previous stage, and
- (iv) An output(s) at each stage appears after a delay in few tens or hundred ns depending upon the type or family of the gate used to implement the circuit

Outline

- Definition
- Representation
- Seven Building Blocks
- Problem Formulation
- Specifications of each output

Combinational circuit representation

- A block diagram for n inputs and m outputs,
- A truth table of 2^n rows,

Combinational circuit representation n inputs, m outputs



Example- Truth Table Four Rows for 2 inputs and 1 output

Inputs		Output
A1	A2	F
0	0	1
0	1	0
1	0	0
1	1	0

Combinational circuit representation

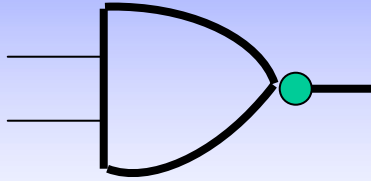
- SOP terms (2^n minterms) for each output
- POS terms (2^n maxterms) for each output
- Karnaugh map of n variables and 2^n cells

Outline

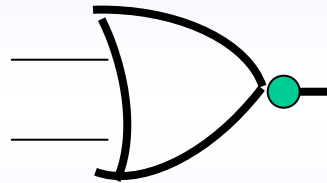
- Definition
- Representation
- **Seven Building Blocks**
- Problem Formulation
- Specifications of each output

3 Building Blocks

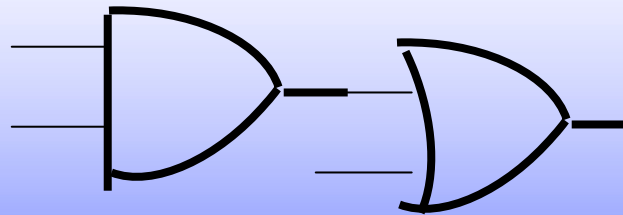
- NAND



- NOR

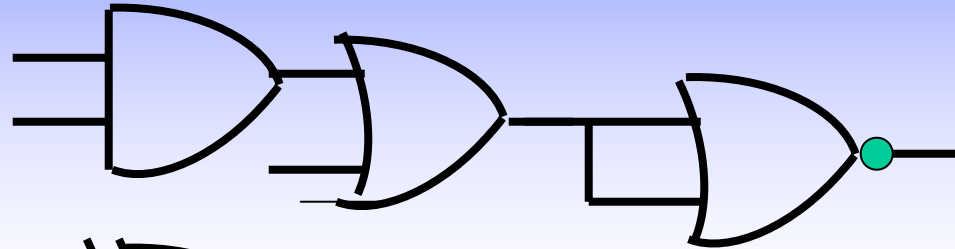


- AND-OR

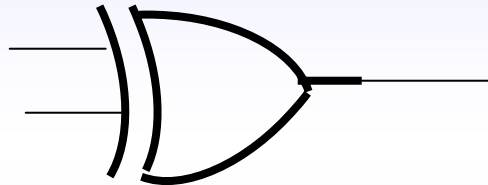


4 Building Blocks

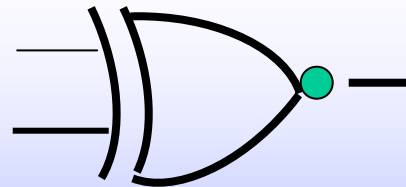
- AND-OR-NOT



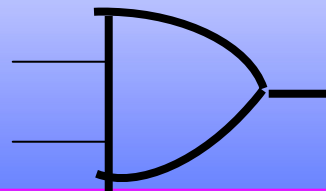
- XOR



- XNOR



- OR-AND



Other Building Blocks

- Decoder
- Multiplexer
- EPLD
- ROM
- FPGA

Outline

- Definition
- Representation
- Seven Building Blocks
- **Problem Formulation**
- Specifications of each output

FORMULATION OF A PROBLEM IN A COMBINATIONAL CIRCUIT

- First step is to select the combinational circuit(s) in a logic network for which the problem of designing as per specifications is to be solved.
- Criteria for whether a problem or its part is solvable by a combination circuit or not, is as follows:

Criteria for whether a problem or its part is solvable

- (i) Check whether the required logic at the output(s) depends only on the input logic conditions, both completely specified by either a truth table or by a Boolean expression,

Criteria for whether a problem or its part is solvable

- (ii) Check whether an output(s) remains same, as long present input condition does not require the change in the output(s), and
- (iii) Check whether an output depends solely on the current input condition and not on any past input condition or past output condition.

Outline

- Definition
- Representation by truth table, miniterm, maxterms
- Seven Building Blocks
- Problem Formulation
- **Specifications of each output**

Specification of each output as a function of input conditions

- 1. Specify the number of inputs, n . The n is also the number of literals in a Boolean expression for an output.
- 2. Specify the number of outputs, m .
- 3. Specify the delays permitted at the outputs

Specification of each output as a function of input conditions

4. Specify the fan-ins permitted at the inputs.
5. Specify fan-outs permitted from the targets gates and building blocks.
6. Design a 'truth table' for n inputs and m outputs. Each output corresponds to each possible combination of input conditions.

Specification of each output as a function of input conditions

7. Write a Boolean expression for the logic circuit for each output: The n is also the number of literals in a Boolean expression for output.
8. Specify as SOP or POS standard Format

Specification of gate characteristics

9. Propagation delays

10. Fan-ins permitted are specified in the problem

Specification of gate characteristics

11. If a possible combination of the input condition is unspecified or is don't care, specify it by 'x'. [The Boolean expression for the output is an incomplete Boolean function.]
12. If a possible condition is high impedance output 'tristate', specify it by '*'

Summary

- A combinational circuit — made up by combining logic gates such that:

Required logic at the output(s) depends only on the input logic present condition,

Both (inputs and output) completely specified by a truth table or Boolean expression

A combinational circuit — Problem Formulation means

- Building block selection
- Defining Specifications

End of Lesson 1

Combinational Circuit

THANK YOU