COMP 202. Introduction to Electronics

Dr. N. B. Gyan

Central University, Miotso. Ghana

Combinational Circuits

- A combinational circuit is an interconnected set of gates whose output at any time is a function only of the input at that time.
- In general terms, a combinational circuit consists of *n* binary inputs and *m* binary outputs.
- As with a gate, a combinational circuit can be defined in three ways:
  - **Truth table**: For each of the 2 n possible combinations of input signals, the binary value of each of the m output signals is listed.
  - **Graphical symbols**: The interconnected layout of gates is depicted.
  - **Boolean equations**: Each output signal is expressed as a Boolean function of its input signals.

Implementation of Boolean Functions

- Any Boolean function can be implemented in electronic form as a network of gates.
- For any given function, there are a number of alternative realizations.
- Consider the following table

A	B	C	F
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	0

Table 1

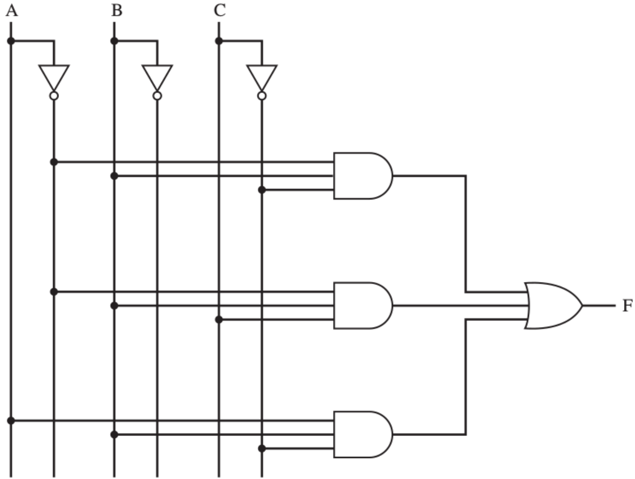
Implementation of Boolean Functions

- We can express this function by simply itemizing the combinations of values of A, B, and C that cause F to be 1:
- Thus,

$$F = \bar{A}B\bar{C} + \bar{A}BC + AB\bar{C} \tag{1}$$

- There are three combinations of input values that cause F to be 1, and if any one of these combinations occurs, the result is 1.
- This form of expression, for self-evident reasons, is known as the *sum of products* (SOP) form.

Implementation of Boolean Functions



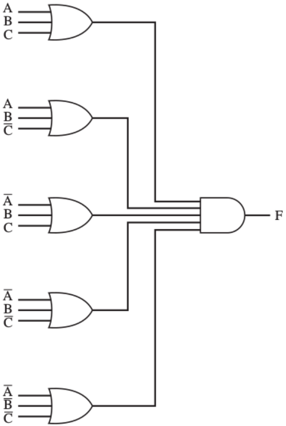
Sum-of-Products Implementation of Table 1 (a straightforward implementation with AND, OR, and NOT gates).

Implementation of Boolean Functions

- Another form can also be derived from the truth table.
- The SOP form expresses that the output is 1 if any of the input combinations that produce 1 is true.
- We can also say that the output is 1 if none of the input combinations that produce 0 is true.
- Thus, $F = \overline{(\bar{A}\bar{B}\bar{C})} \cdot \overline{(\bar{A}\bar{B}C)} \cdot \overline{(A\bar{B}\bar{C})} \cdot \overline{(A\bar{B}C)} \cdot \overline{(ABC)}$
- This can be rewritten using a generalization of DeMorgan's theorem:

  $\overline{(X \cdot Y \cdot Z)} = \bar{X} + \bar{Y} + \bar{Z}$, thus,
- $F = (\bar{\bar{A}}+\bar{\bar{B}}+\bar{\bar{C}})\cdot(\bar{\bar{A}}+\bar{\bar{B}}+\bar{C})\cdot(\bar{A}+\bar{\bar{B}}+\bar{\bar{C}})\cdot(\bar{A}+\bar{\bar{B}}+\bar{C})\cdot(\bar{A}+\bar{B}+\bar{C})$
- $F = (A+B+C)\cdot(A+B+\bar{C})\cdot(\bar{A}+B+C)\cdot(\bar{A}+B+\bar{C})\cdot(\bar{A}+\bar{B}+\bar{C})$
- This is in the *product of sums* (POS) form.

Implementation of Boolean Functions



Product-of-Sums implementation of Table 1. For clarity, NOT gates are not shown. Rather, it is assumed that each input signal and its complement are available. This simplifies the logic diagram and makes the inputs to the gates more readily apparent.

Implementation of Boolean Functions

- Thus, a Boolean function can be realized in either SOP or POS form.
- At this point, it would seem that the choice would depend on whether the truth table contains more 1s or 0s for the output function: The SOP has one term for each 1, and the POS has one term for each 0.
- However, there are other considerations:
  - It is often possible to derive a simpler Boolean expression from the truth table than either SOP or POS.
  - It may be preferable to implement the function with a single gate type (NAND or NOR).

Implementation of Boolean Functions

- The significance of the first point is that, with a simpler Boolean expression, fewer gates will be needed to implement the function.
- Three methods that can be used to achieve simplification are
  - Algebraic simplification
  - Karnaugh maps
  - Quine-McKluskey tables

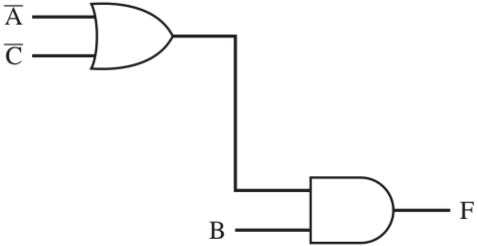
Algebraic Simplification

- Algebraic simplification involves the application of the identities (earlier in the notes) to reduce the Boolean expression to one with fewer elements.
- For example, consider again the equation (1) we looked at with function F.
- Some thought should convince the reader that an equivalent expression is (take this as an assignment)

  $F = \bar{A}B + B\bar{C}$
- Or, even simpler,

  $F = B(\bar{A} + \bar{C})$
- The simplification was done essentially by observation.
- For more complex expressions, some more systematic approach is needed.

Algebraic Simplification



Simplified Implementation of Table 1

LAB & Assignment

Work and present the assignment in the slides on VCampus.
For LAB *verify* that the simplified circuit works the same as the earlier one shown.