Laboratory Two

Simplification of Logic Circuits

Basic Concepts

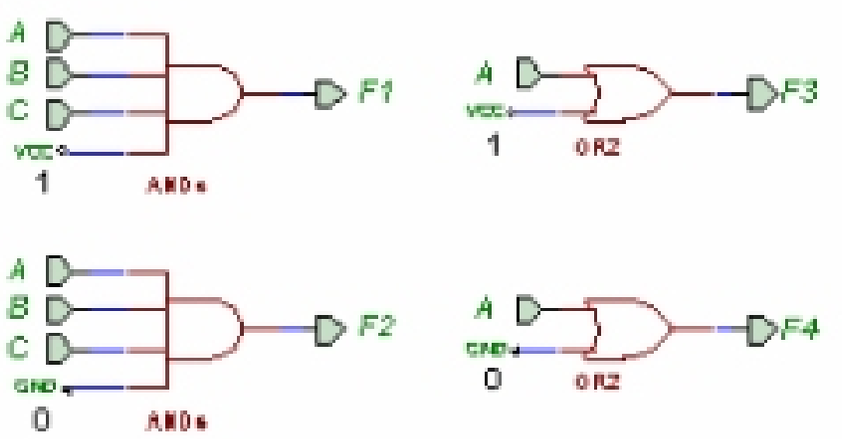
1. Logic circuits realize Boolean expressions.
2. Logic circuits may be simplified by applying Boolean postulates and theorems.
3. Equivalent logic circuits have the same truth table.

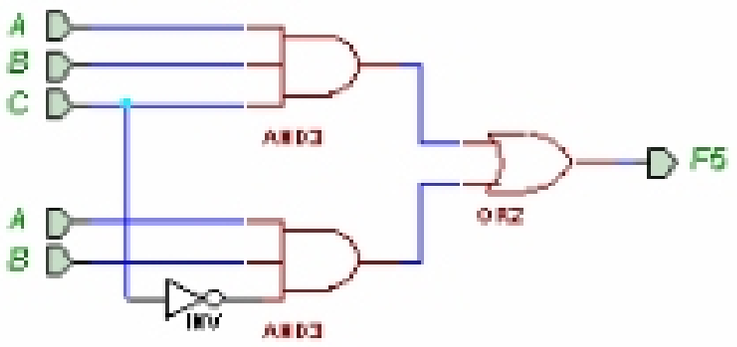
Note: Steps marked with (Pre) below, indicate prelab work to be done and recorded in your laboratory notebook before coming to lab.

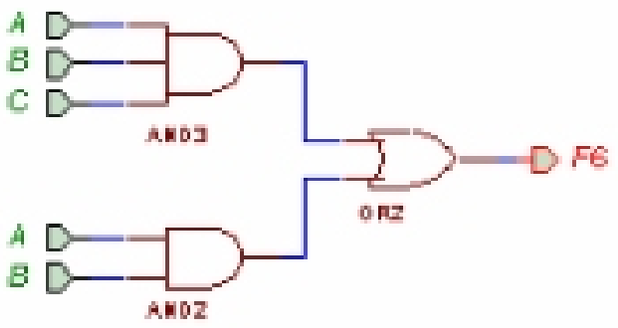
Task One: Expressions from Circuits

Consider the logic circuits shown to the right.

1. (Pre) Draw circuits F_1 through F_6 in your lab notebook, and mark pin numbers next to each input and output terminal. [For the 4-input **AND** (which we don't have), use the 7420 **NAND**, followed by a 7404 inverter.] See: SSI data sheet.
2. (Pre) Derive a Boolean expression for each circuit F_i in your notebook, showing your steps of calculation.
3. (Pre) Draw a *theoretical* truth table for the F_i in terms of inputs ***A***, ***B*** and ***C*** (for F_3 and F_4 just use ***A***). (To save space, consider drawing one long horizontal table showing the various terms of the F_i in columns after ***A***, ***B*** and ***C***.)
4. (Pre) Simplify your expression for the F_i using the Boolean algebra postulates and theorems given in the notes, stating which property(ies) you are using (for example, you may want to write the "absorption" or one of the "identity" properties). Draw a simplified circuit for each F_i.
5. In the lab, build the original and simplified circuits for F_1 through F_4 and check to see if they behave the same (flip the switches and watch how the output lights go on and off for each circuit). Do not disassemble any of your F_i circuits.
6. Finally, build the original and simplified circuits for F_5 and F_6, using your wired circuits F_1 through F_4 as a starting point. Record *experimental* truth tables for F_5 and F_6.







Task Two: Circuits from Expressions

1. (Pre) Draw logic circuits which exactly reproduce F_7 through F_{10} shown at right (do not attempt to simplify or rewrite the expressions). You may use any gates that are available in the ***Xilinx*** library (no pin numbers are required here, by the way).
2. (Pre) Draw the theoretical truth table for the F_i in terms of A, B and C.
3. (Pre) Next, simplify the F_i using the techniques learned in **Task One**. (These problems will require multiple application of the Boolean theorems.) Draw the resulting simplified circuits in your notebook.
4. Enter the logic circuits for both the original and simplified expressions for the F_i into ***Xilinx's*** **Schematic Editor**. Employ the **Functional Simulation** and design an arrangement to test all eight circuits simultaneously and prove that the original and simplified circuits are equivalent. From your simulation results, record an *experimental* truth table in your lab notebook for the F_i. How do these results compare with your theoretical results?

$$F_7 = A\overline{B}(A+\overline{B}+\overline{B}\,\overline{C})$$

$$F_8 = (A+B)(B+C)(A+C)$$

$$F_9 = \overline{ABC}+\overline{A}\,\overline{B}\,\overline{C}$$

$$F_{10} = \overline{(A+\overline{B})C+B\overline{C}+A}$$