ECE 301 Digital Electronics

Combinational Circuits

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OBJECTIVE

To learn basic combinational circuit design and construction.

To learn to build and troubleshoot combinational logic circuits.

PREPARATION

Design and construct the required circuits.

PROCEDURE

1. Given the following function:

$$F(A,B,C) = A + \left(A + \overline{B}\right) \bullet \left(\overline{B} \bullet \overline{C}\right)$$

   - Design and implement the circuit for the function as written
   - Generate the truth table for the circuit that you've designed and implemented.

2. Simplify the equation of 1 above.

   - Design and implement the simplified equation with another set of chips
   - Verify that the new circuit output agrees with the truth table of equation 1

3. A major component of the design process is the testing and the discovery of design flaws and circuit faults.

   - Design flaws are the result of the misinterpretation of the specification or incorrect design technique.
   - Circuit faults can arise from poor implementation (in this class your wiring is may be in error) or faulty components (an input or an output stuck at a 1 or 0 due to an internal failure of the component).

4. Other problems can give rise to circuits that fail to function as intended. Ionizing radiation (rare on earth, of concern in satellites) can cause memory cells to temporarily change value (soft failure) without damaging the circuit as well as cause physical damage, temperature can

change propagation delays, hook-up wire with invisible internal breaks can act as an open circuit from output to input (with the input usually floating to a high-logic level), failure to properly connect grounds to the circuit and your logic probe or oscilloscope can give erroneous readings, and wires broken off in the breadboard can short cells together. Though some problems are more common than others, all can interfere with the effective and correct implementation and operation of a digital circuit.

5. No simple solution exists for isolating the cause of a particular circuit to fail to behave as expected. An effective systematic approach is to observe the logic values from input to output within the circuit to locate a fault (there may be more than one). Since these are combinational circuits with no feedback (as in sequential circuits studied later in the course), the fault must occur before the error which has been located. One way to perform signal tracing through the circuit is to connect a logic light to each node from input to output in the circuit and verify that the circuit up to that point behaves in accordance with the Boolean function implemented at that node.

    - As a simple example in the following circuit, the correct operation of Gate 1 can be checked by probing node Y and toggling the input B (Y is B-bar, the complement of the value at Y).

    - Notice that the correct connection of the output of Gate 1 must be verified for both the inputs of Gate 2 and Gate 3 for the rest of the circuit to operate correctly.

6. Path sensitization can also be used to allow an internal node in a circuit to be visible on the output. When input A is a logic one, the value of X will appear at the output. (Explain why. What is the Boolean value of X?) Sometimes it may be necessary to partition the circuit into sub-circuits to allow observations of all the possible faults.

7. Examine the circuit below by probing all the circuit nodes (V, W, X, Y, Z) and listing the values in a truth table.

8. Write the Boolean equation for each node.

9. For each node (V, W, X, Y, Z) in the circuit, determine and specify in your report the values of the input variables (A,B,C) that will allow the value of the node to appear at the output and verify this experimentally.