ELT-217, **Experiment AD1**:Simple Gates

OBJECTIVE:

To use the Analog Discovery to investigate some simple operations of IC AND and OR gates

EQUIPMENT NEEDED:

Analog Discovery and computer
Variable Power Supply; leads and cables as needed
1K resistor
7411, 7432, chips and circuit diagrams for chips
Breadboard

BACKGROUND:

When logic gates are actually implemented electrically the exact voltages which correspond to a "high" or a "low" must be defined. Although the nominal voltages are 0V for low and +5V for high, these are not the actual voltages during circuit operation. For standard commercial TTL (the other TTL families are very similar), assuming V_{CC}=5V, the following voltage levels are typically defined:

(a) voltage on an *input* which will be seen as low: 0-0.8V
(b) voltage on an *input* which will be seen as high: 2.0-V_{CC}
(c) voltage produced by an *output* when low: 0-0.4V
(d) voltage produced by an *output* when high: 2.4-V_{CC}.

Note that in all cases an *output* will always fall within the spec's for an *input* even allowing for tolerances. Thus a LOW *output* should never be higher than 0.4V; this will always be seen as a low by an *input* which sees anything less than 0.8 volts as a low. Similarly a HIGH *output* should always be more than 2.4V; this will always be seen as high by an *input* which sees anything more than 2.0V as a high. Input voltages between the maximum for a low (0.8V) and the minimum for a high (2.0V) may be seen by an IC as either high or low, the manufacturer does not guarantee which.

PROCEDURE:

Note: Where data is required your report should have a neat data table for each step. Where circuits are wired, you must have a neat diagram showing pin numbers and functional interconnections for each step. The circuit diagrams must be included in your report. In your report state whether the results on each output point are as expected and why; explain as necessary.

A. Simple AND and OR Gates.

(1) Wire up one section of a 7411 3-input AND gate using three logic switches to provide inputs and one of the virtual LED's to monitor the output. Verify the truth table for this gate (in your report include the data taken in the form of a truth table--show data taken and compare to expected outputs). Use the virtual voltmeter to check the voltages on the output for all

"highs" and "lows"; discuss if they within the tolerances given in the background section above.

(2) Remove the connection to one of the inputs of the 7411 and let it "float" (connect to nothing). Draw a 4-line truth table for the remaining 2 inputs. From this table explain why the floating input looks like either a "high" or a "low".

(3) Wire up one section of a 7432 2-input OR gate using two logic switches to provide inputs and one of the LED's to monitor the output. Verify the truth table for this gate (in your report include the data taken in the form of a truth table -- show data taken and compare to expected outputs). Use a voltmeter to check the voltages on the output for all "highs" and "lows"; discuss if they are within the tolerances given in the background section above.

(4) Remove the connection to one of the inputs of the 7432 and let it "float". Draw a 2-line truth table for the remaining input. Do you conclude that this floating input looks like either a "high" or a "low"? Are your conclusions about floating inputs the same as in step 2? Justify your answer.

(5) Disconnect the inputs of the 7432 from the logic switches and connect one input to ground. Attach the other input of the 7432 to a variable power supply so you can apply a variable voltage to that input. Monitor the voltage on that input with the Analog Discovery voltmeter and slowly vary the voltage from 0V to 5V; observe the output of the 7432 and note when it changes. In your report discuss if it falls within the voltage tolerances given in the background section.

<u>B. Complex AND and OR Circuits.</u>

(1) Construct a 4-input AND gate by using two sections of the 7411 with the unused input pulled high as shown in figure 1. Construct the truth table by testing and finding the output, F, for each of the 16 possible combinations of input variables. Then prove F=ABCD from an evaluation of the truth table.

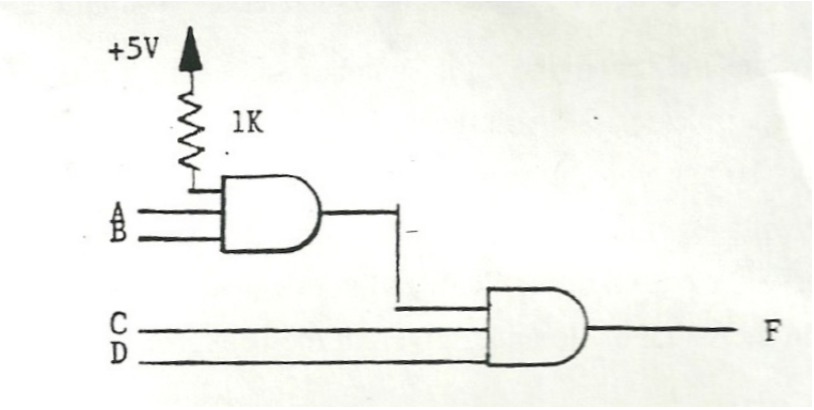

Figure 1,
4-input AND gate

(2) Construct a 4-input OR gate by using four sections of the 7432 as shown in figure 2. Construct the truth table by testing and finding the output, F, for each of the 16 possible combinations of input variables. Then prove F=A+B+C+D from an evaluation of the truth table.

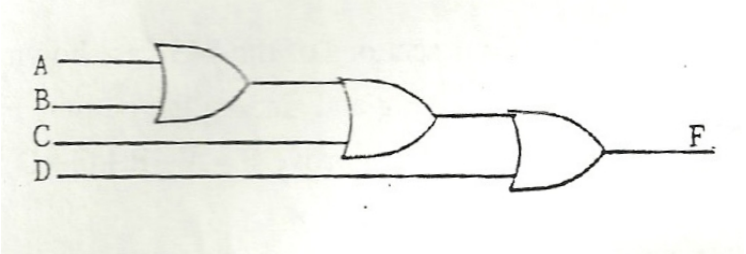

Figure 2,
4-input OR gate

(3) Construct the circuit shown in figure 3. Construct the truth table and derive the logical expression for the output, F.

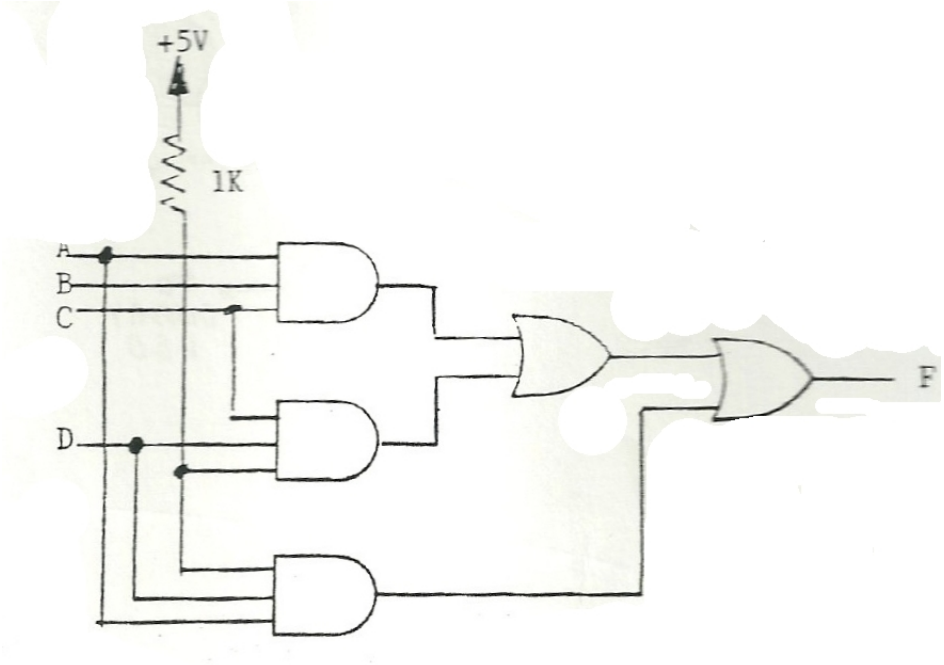

Figure 3,
Combination Circuit