EE 462: Laboratory # 3
Logic Circuits Using Diodes

by
Dr. A.V. Radun
Dr. K.D. Donohue (9/11/03)
Department of Electrical and Computer Engineering
University of Kentucky
Lexington, KY 40506

Laboratory # 3 Pre-lab due at lab sessions September 23, 24, and 25.
Lab due at lab sessions September 30, October 1, and 2.

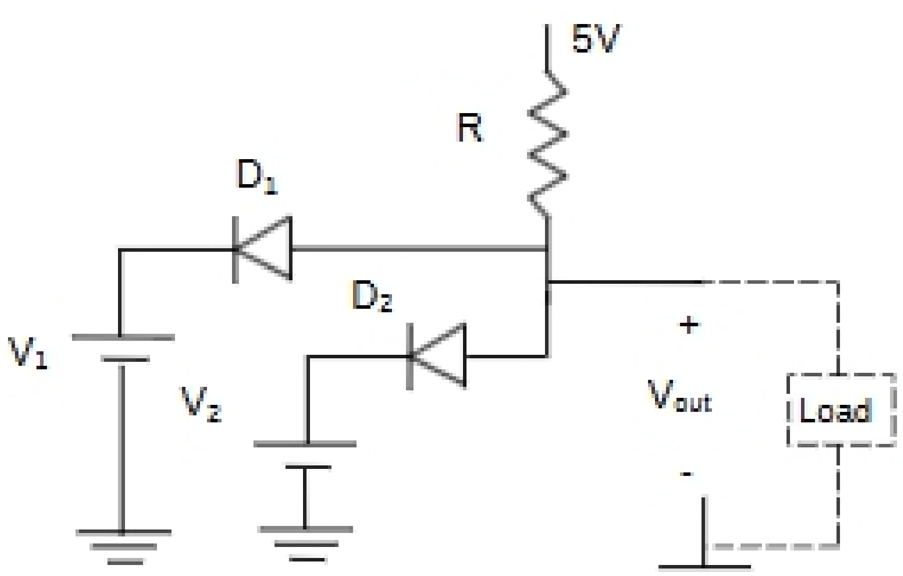
I. Instructional Objectives

- Analyze and measure diode logic circuits
- Understand the limitations of DVMs (digital volt meters)
- Understand the triggering operation and coupling option on oscilloscopes
- Apply proper oscilloscope setting to measure signals with AC and DC components

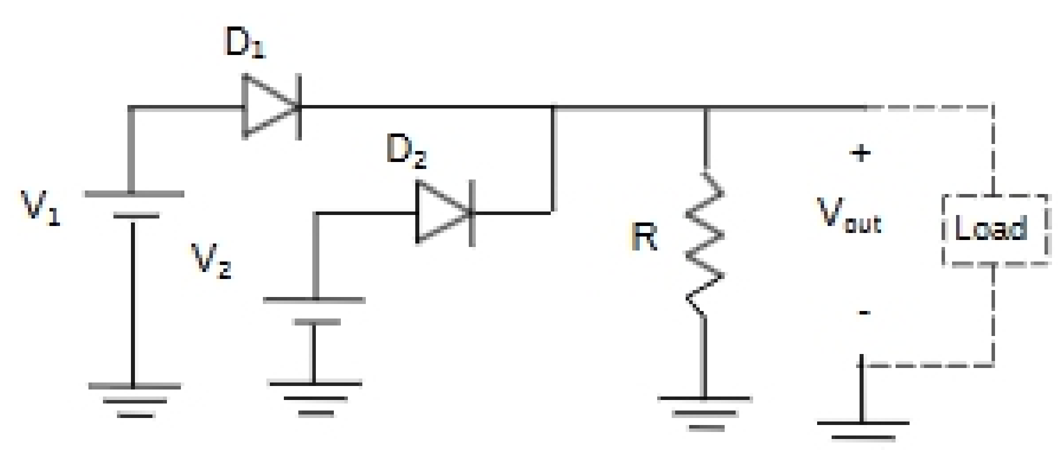
See Horenstein Chapters 3 and 4

II. Background

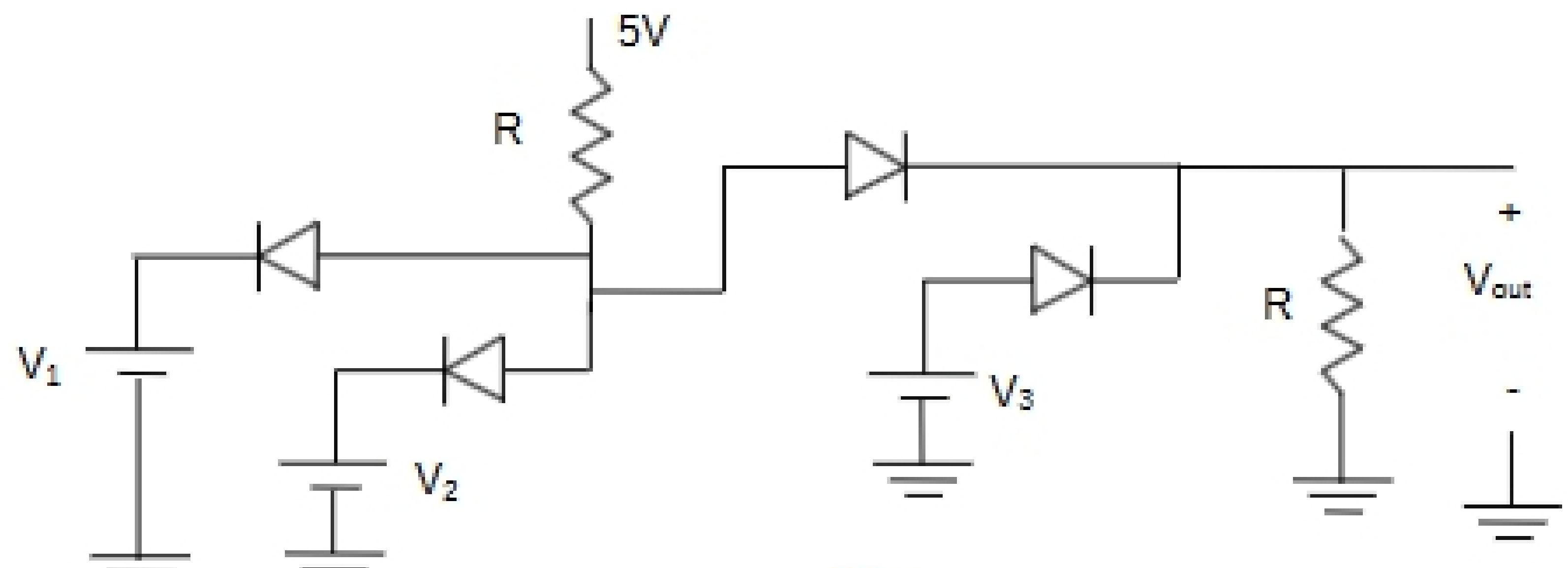
Circuits in Figs. 1A and 1B implement two basic diode logic gates. For five-volt positive logic the input voltage is either 5V or 0V representing logic 1 or logic 0, respectively. Combinations of these basic logic circuits form more complex logic circuits. For the circuits of Fig. 1, the inputs are designated as V_1 and V_2, (and V_3 for Circuit C), and output is V_{out}.



(A)



(B)



(C)

Fig. 1. Diode logic gates for analysis and measurement: (A) Circuit A, (B) Circuit B, (C) Circuit C.

For the following pre-lab problems, assume that the input high voltage (V_{IH}) equals 5V, the input low voltage (V_{IL}) equals 0V (See pg. 350 in Horenstein for the definitions.), and R = 10kΩ.

III. Pre-laboratory Exercises

For the pre- lab problems, assume that the input-high voltage (V_{IH}) equals 5V, the input-low voltage (V_{IL}) equals 0V (See pg. 350 in Horenstein for the definitions.), and R = 10kΩ.

1. Determine the truth tables for the Circuits A and B, and indicate the type of logic gates they represent (R_{load} = infinite).
2. For Circuit A determine the values for voltage output low (V_{OL}) and voltage output high (V_{OH}) (See pg. 350 in Horenstein for the definitions.) with no load (R_{load} = infinite).
3. Plot the transfer characteristic of Circuit A (V_{out} versus V_1) for the case where V_2 is high (5V). Indicate the slope (numerically) of the transfer characteristic for regions where it is non-zero, and the axis intercepts. Sketch the ideal transfer characteristic for the gate that this circuit represents.
4. Plot the transfer characteristic of Circuit B (V_{out} versus V_1) for the case where V_2 is low (0V). Numerically indicate slope of the transfer characteristic for regions where it is non-zero, and the axis intercepts.
5. Determine the truth table for Circuit C and indicate its logic expression (combination of gates).
6. For Circuit C determine the values of V_{OL} and V_{OH}.
7. Determine the theoretical rms value of a 100Hz, 10Vp-p sine wave offset by 3V (3V_{DC} added to the sine wave).
8. Determine the theoretical rms value of a 10kHz, 0V to 10V square wave.

IV. Laboratory Exercises

Use R = 10kΩ with IN4001 diodes.

1. Put a 100Hz 10Vp-p sine wave into your oscilloscope. Trigger at the middle of the screen, on DC, a positive slope and 0V. Record your waveform. Trigger at the middle of the screen, on DC, a positive slope and *a little less than* 5V. Record your waveform. Indicate on your waveforms where they are triggered.
2. Put a 100Hz 10Vp-p sine wave into your oscilloscope and trigger on the waveform. First put the scope vertical on AC, and then on DC. For each case use the measure menu to have the scope compute the waveform's average and rms value. Record the measured average and rms voltages in each case. (**Discussion: Compare measured and theoretical rms values. Provide reasons for any differences in the values.**) DO NOT record the waveform for this part. Repeat for frequencies of 10Hz, 1kHz, 10kHz and 100kHz.
3. Use the DMM to measure and record the same voltage with the meter first on AC and then on DC. Repeat for frequencies of 10Hz, 1kHz, 10kHz and 100kHz. (**Discussion: Compare results with that measured in Procedure 2.**) (**Discussion: What conclusions can you draw about the scope and the voltmeter? How are they the same and how are they different?**)
4. Put a 100Hz 10Vp-p sine wave offset by 3V into your oscilloscope. You can do this using the offset control on the signal generator. (***Important!!!! Do not put the signal generator in series with the DC lab power supply. Doing so can cause catastrophic damage to the signal generator.***) Put the scope vertical on DC. Trigger at the middle of the screen, on DC, a negative slope and 3V. Record your waveform. Trigger at 90% of the screen, on DC, a positive slope and 6V. Record your waveform. Indicate on your waveforms where they are triggered.
5. Put a 200Hz 10Vp-p sine wave offset by 3V into your oscilloscope and trigger on it. Put the scope vertical first on DC and then on AC. For each case use the measure menu to have the scope compute the waveform's average and rms value. Record the measured average and rms voltages in each case. (**Discussion: Compare measured and theoretical rms values.**) DO NOT record the waveform for this part. Repeat for frequencies of 20Hz, 2kHz, and 20kHz.
6. Using your VOM, measure and record the same voltage as in Procedure 5 with the meter first on AC and then on DC. Repeat for frequencies of 20Hz, 2kHz, and 20kHz. (**Discussion: Compare results with those measured in Procedure 5. What conclusions can you draw about the scope and the voltmeter? How are they the same and how are they different?**)
7. Build Circuit A with R = 10k□. Verify the circuit's truth table by recording the input and output voltages. Record the values of V_{OL} and V_{OH} with no load (R_{load} = infinite).
8. Insert a load of 40k□□at the output of Circuit A and measure V_{OL} and V_{OH}. (**Discussion: Consider a specification that V_{OH} must be greater than 4V with a load equal to 4kW. What is the constraint on the value of pull-up resistor R for this condition? What is the price (disadvantage) of being able to drive a load with a small R_{load} value?**)
9. Measure the transfer characteristic of Circuit A with R_{load} = 40k□□(V_{out} versus V_1) for the case where V_2 is high (5V) and V_1 is equal to a 1kHz, 0V to 5V triangle waveform. Record the transfer characteristic. Record the waveform on the screen representing the transfer characteristic. (**Discussion: Indicate on the measured transfer characteristic when D_1 is on and when it is off. What is the state of D_2 for this measurement (on or off)?**)
10. Measure and record the high to low and low to high delay times, the rise time, and the fall time with the input a 1kHz, 0V to 5V square wave (see Fig. 2). DO NOT record the waveforms for this part.