# Lab 1 CMOS Parameters

## EET 207

Lab 1 is intended to allow the student of EET 207 to become familiar with several TTL devices, and measure some of their parameters. Six circuits are tested. Each has specific measurements to be taken. The circuits will be built on the breadboard kits available in the lab. Be careful when inserting, connecting and bending pins and wires which are delicate. If something needs to be forced, chances are it is not supposed to be done in that manner.

**Circuit 1 Input and Output current, and output voltage:**

Circuit 1 is shown in Figure 1

**Test equipment needed:**

- 2DMMs to measure current and voltage
- Power Supply. Use the 5 V output.

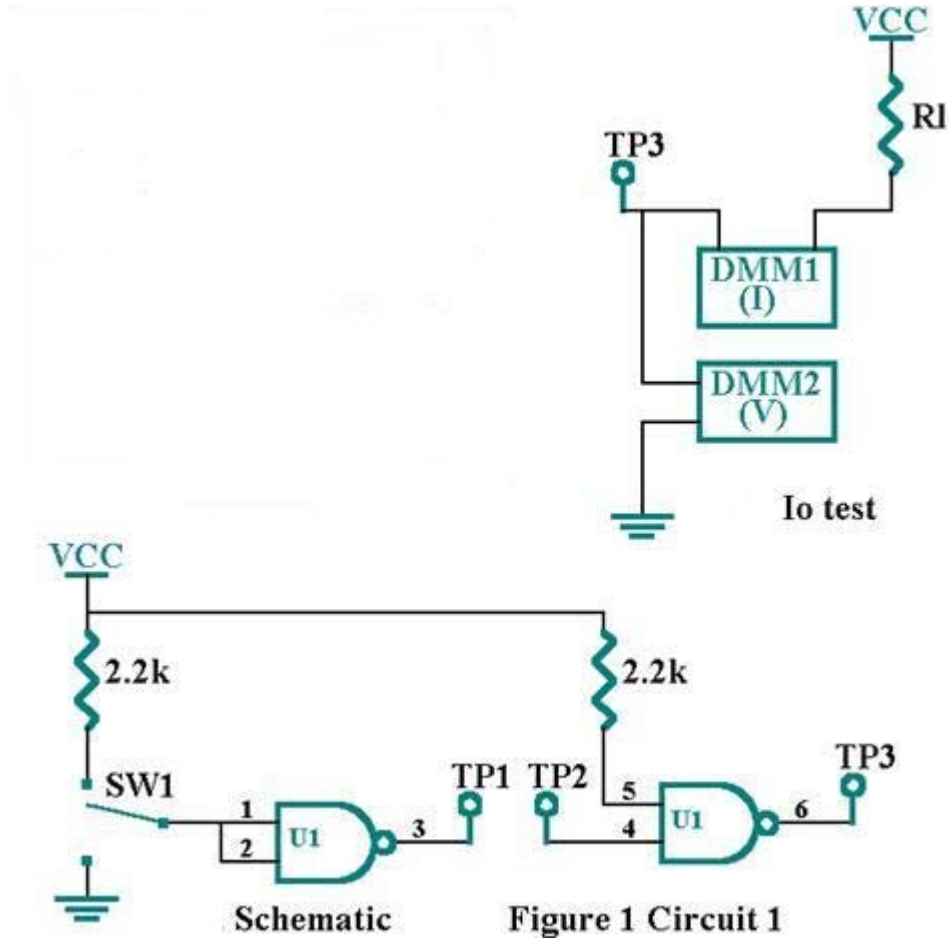



Figure 1 Circuit 1

**Typical input current and output voltage procedure**:

Measure typical input current.

- Connect Circuit 1 to the 5V-power supply.
- Measure and record the 5V-power supply voltage.
- Connect one DMM to measure current, between TP1 and TP2.
- Connect the other DMM to measure voltage between ground and TP1.
- Switch SW1 to the "up" position. This setting will supply a 1 to pins 1 and 2 of the 74ACT00, which will supply a 0 to TP1.
- Measure and record the voltage between TP1 and Ground. What parameter are you measuring?
- Measure and record the current between TP1 and TP2. What is the sign of the current at the input pin 4? (Remember positive current always flows into a device pin.) What parameter are you measuring?
- Switch SW1 to the "down" position. This setting will supply a 0 to pins 1 and 2 of the 74ACT00, which will supply a 1 to TP1.
- Measure and record (and label) the voltage between TP1 and Ground.
- Measure and record (and label) the current between TP1 and TP2. Again pay attention to the sign.

- Explain the differences between these readings and the parameters given in the data sheet. (Look at the part and find the datasheet on the Internet. If you cannot find the same manufacturer of the chip a similar manufacturer will work)
- A 2.2 k Ω resistor is used for a pull up. What is the maximum (use data sheet parameter here) voltage drop expected across the resistor? Do not calculate the value of the resistor pulling up pin 5 to Vcc. Therefore what voltage should be being applied to pin 5 of the IC?

**Output current and voltage procedure:**

Use circuit 1 to observe the output voltage current curve for a 1 and a 0 output.

- Circuit 1 should still be connected to the 5V-power supply.
- Place a jumper between TP1 and TP2.
- Check that Switch SW 1 is in the "down" position. This setting will produce a 0 at TP3.
- Set up the two DMMs as shown in Figure 1C. One is measuring the voltage between TP3 and Ground. The other is measuring current through RL.

Note: RL is the load resistor. The function is to induce current on the output of your pin 6 output pin. If RL, is not there, there would not be any current path and this section could not be completed.

- Start with a 10K Ω resistor as RL. Record the voltage and current. What is the sign of the current?

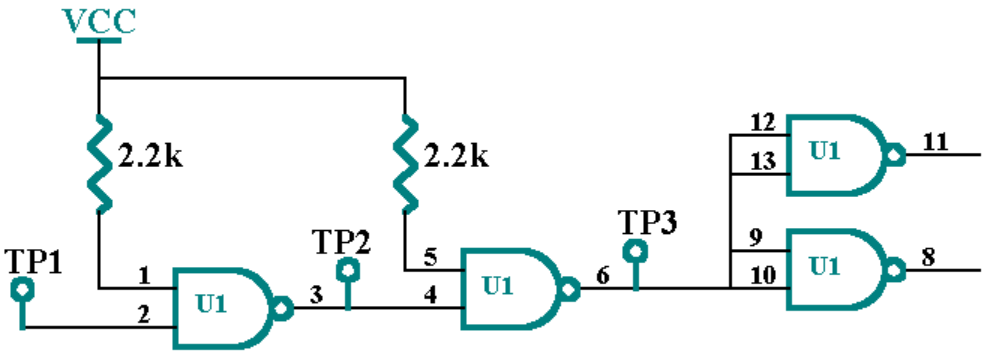
- Substitute lower value (and higher if you think that will show anything interesting) resistors for RL. Record the voltage and current. What would indicate that you have substituted a low enough value resistor? In other words, when should you stop?
- Graph the voltage and current readings. What parameters are being shown?
- Switch SW1 to the "up" position to produce a 1 at TP3.
- Repeat the procedure above to measure the Voltage Current curve for a 1 output.
- How must you change the test circuit to make these measurements? Now what is the sign of the current?
- Are the stopping points different, or the stopping criteria different?
- What do the comparisons of the two graphs tell us about TTL logic?
- Compare these graphs with the readings made in the typical input current and output voltage above.

**Circuit 2 Propagation delay:**

Circuit 2 is shown in the figure 2 below. The procedure is shown below.

**Test equipment needed:**

- Oscilloscope (fastest we have)
- Function Generator.
- Power Supply w/ Digital Voltmeter. Use the Positive variable output.




B. Schematic Figure 2 Circuit 2

**Propagation Delay Procedure:**

Use circuit 2 to observe propagation delay through one section (pins 4, 5, 6) of a 74ACT00.

- Use the Oscilloscope to adjust the function generator to produce the following signal:

- Square wave
- Frequency ≈ 10Khz

- Amplitude 3V
- DC min between 0V and 0.4V

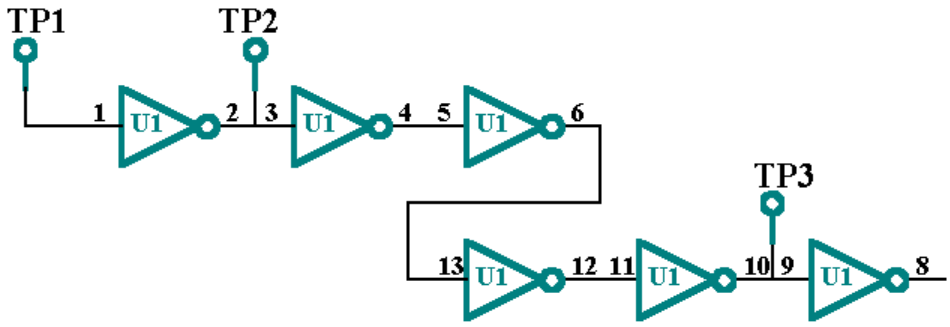
- Use the built in Digital Voltmeter to adjust the Power supply to 5.00V.
- Connect the power supply to Ground and VCC on the board.
- Connect the function generator to TP1.
- Use the Oscilloscope to be sure that the signal at TP1 is still as specified.
- Connect Channel 1 to TP2, and Channel 2 to TP3. Which signal should you be triggering off of?
- Measure rise and fall time on TP3 (Typically this is defined as 10% to 90% of the transition of the wave).
- Measure Propagation delay (50% to 50%) between TP2 and TP3.
- Observe and record (roughly) the waveforms as you vary the power supply from 4.5V to 5.5 V. Do you notice anything change visually? (In this step you do not need to record any data, just if you notice anything)
- Adjust the power supply to 4.5 volts.
- Measure rise time, fall time, and propagation delay.
- Adjust the power supply to 5.5 volts.
- Measure rise time, fall time, and propagation delay.
- What are the two gates (pins 8 through 13) being used for in this circuit?

**Circuit 3 Propagation delay, multiple gates:**

Circuit 3 is shown in Figure 3. Use the Propagation delay procedure used for Circuit 2 above. Compare the results.

**Test equipment needed:**

- Oscilloscope
- Function Generator.
- Power Supply w/ Digital Voltmeter. Use the Positive variable output.




**B. Schematic** **Figure 3 Circuit 3**

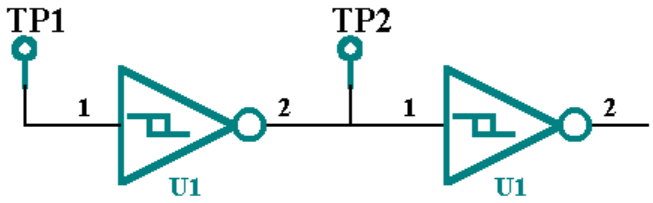
**Circuit 4 Schmitt-Trigger (74ACT14) :**

Circuit 4 is shown in Figure 4.

Circuit 4 shows the action of a Schmitt-Trigger inverter. With a normal gate, the input signal must transition quickly between $V_{il}$ and $V_{ih}$, or vice versa. A Schmitt-Trigger does not have $V_{il}$ or $V_{ih}$. A Schmitt-trigger has, instead, a $V_{T+}$, and $V_{T-}$. When the input voltage goes above $V_{T+}$, the output switches to 1. When the input voltage goes below $V_{T-}$, the output switches to 0. These devices are useful to interface with the "outside world" which is not digital. The experiments here will involve inputting sine and triangle waves into the 74ACT14. Care must still be taken not to exceed absolute maximum ratings, which include keeping $V_i$ less then 7 Volts. The lab procedure is below.

**Test equipment needed:**

- Oscilloscope
- Function Generator.
- Power Supply. Use the 5 V output.




**B. Schematic** **Figure 4 Circuit 4**

**Schmitt-Trigger Procedure:**

Use circuit 4 to observe Schmitt-Trigger action through one section (pins 1 and 2) of a 74ACT14.

- Use the Oscilloscope to adjust the function generator to produce the following signal:

- Sine wave
- Frequency ≈ 10Khz

- Min voltage between 0V and 0.4V
- Max voltage between 2.0V and 4.0V

- Connect Circuit 1 to the 5V-power supply.

- Connect Channel 1 to TP1, and Channel 2 to TP2.

- Observe and record the two traces.
- Being careful not to exceed maximums, adjust the input waveform (shape, amplitude, and DC offset) and observe the result.
- In your report, define the term "Hysteresis".

**Circuit 5 Flip-Flop Propagation:**

Circuit 5 is shown in Figure 5. The procedure is shown below.

**Test equipment needed:**

- Oscilloscope
- Function Generator

- Power Supply. Use the 5 V output.

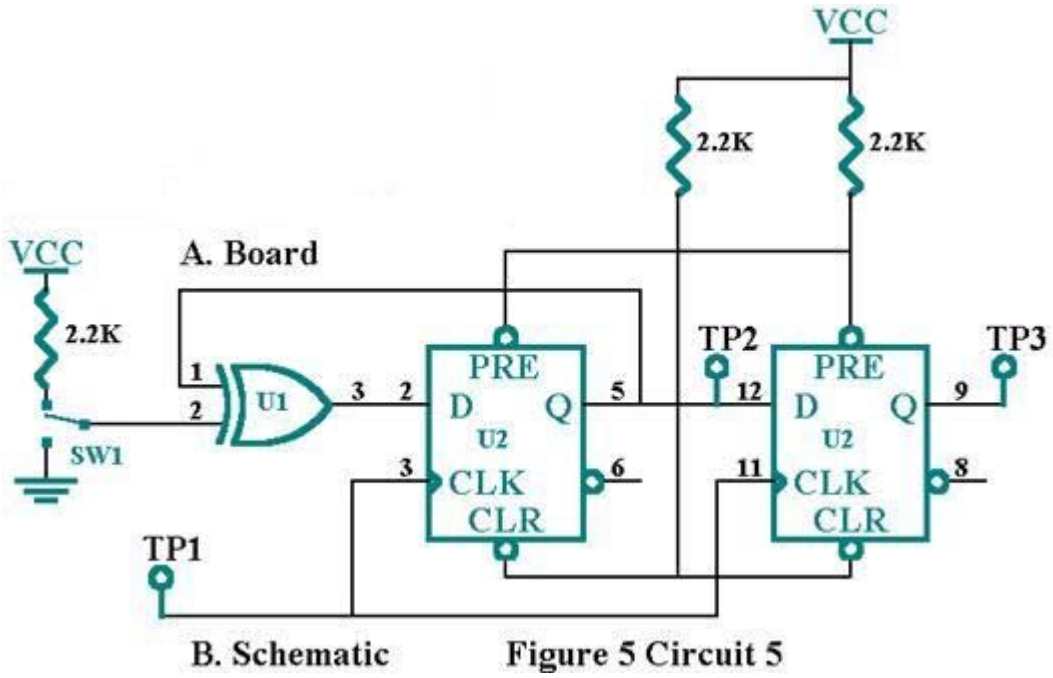


Figure 5 Circuit 5

**Flip-Flop Procedure:**

Use circuit 5 to observe D Flip-Flop behavior.

- Use the Oscilloscope to adjust the function generator to produce the following signal:

- Square wave
- Frequency ≈ 10Khz
- Amplitude 3V

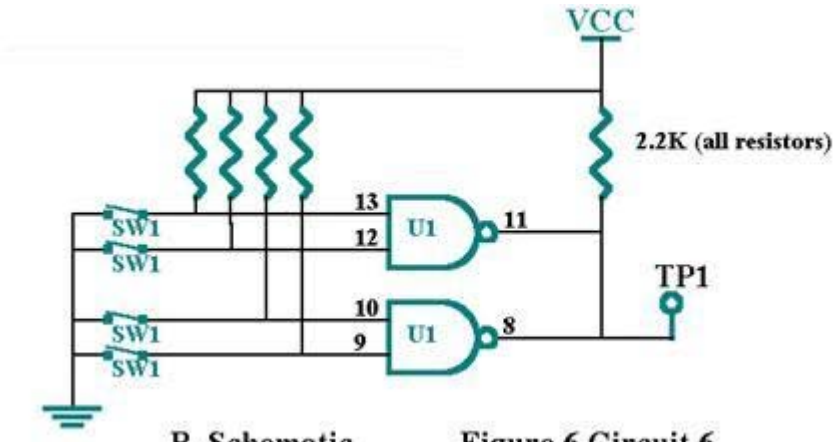
- DC min between 0V and 0.4V
- Connect circuit 5 to the 5V supply.
- Connect the Function Generator to TP1.
- Connect Channel 1 to TP1. Connect Channel 2 to TP2.
- Switch SW1 to the "up" position.
- Observe and record the waveforms on TP1 and TP2. Which signal do you need to trigger on?
- Measure the propagation delay between TP1, and TP2. (50% to 50%)
- Move SW1 to the "down" position. Observe. Which signal do you need to trigger on now.
- Move SW 1 back to the "up" position, and move Channel 2 to TP3, and Channel 1 to TP2.
- Move Channel 1 back to TP1. Measure the propagation delay between TP1 and TP3.
- Compare the propagation delays from TP1 to TP2 and to TP3. What does this mean about the condition between TP1 and TP2?

**Circuit 6 Open Collector:**

Circuit 6 is shown in Figure 6. The procedure is shown below.

**Test equipment needed:**

- Power Supply. Use the 5 V output.
- Logic Probe




B. Schematic Figure 6 Circuit 6

**Open Collector Procedure:**

Use circuit 6 to observe Open Collector behavior

- Connect Circuit 6 to the 5-volt supply.

- Build a truth table of the output TP1 based on SW1, SW2, SW3, SW4 inputs to the open collector gates.
- What is the Boolean algebra function of the inputs to the outputs?
- Discuss advantages and disadvantages of Open Collector logic.