Lab 6: Digital Circuits

6.0 Prelab

0. None.

6.1 Components

Analog Discovery 2 module
MC14007 MOSFET chip

6.2 Task 1: CMOS Inverter

1. Use a circuit simulator to simulate the voltage transfer characteristics (VTC) of a CMOS inverter. Refer to your Lab 3 or your textbook for the circuit. Set the model properties for your MOSFETs so that the NMOS has k = 0.6 mA/V^2 and V_T = 1.5V and the PMOS has k = 0.6 mA/V2 and V_T = -1.5V. Use a single supply of 5V. (In PSpice, you plot a transfer characteristics by first plotting the trace for the output voltage then changing the axis settings to plot the input voltage on the x-axis.)
2. Change k_n to 0.3 mA/V^2 and record the change in the VTC.
3. Change k_n to 1.2 mA/V^2 and record the change in the VTC.
4. Change V_{TN} to 1 V and record the change in the VTC.
5. Change V_{TN} to 2 V and record the change in the VTC.
6. Change V_{TN} back to 1.5 V, change V_{TP} to -2V, and record the change in the VTC.

6.3 Task 2: Ring Oscillator

7. Construct a circuit using your MOSFET chip wired according to the following instructions:
    a. Connect pins 2, 11, and 14 to the positive supply. Use V+ from the AD2 as the positive supply and set it to +5V.
    b. Connect pins 4, 7, and 9 to ground.
    c. Connect pins 1, 5, and 6.
    d. Connect pins 8, 10, and 13.
    e. Connect pins 3 and 12.
8. Start the supplies and run the scope. You should observe a periodic signal that varies between 0 and 5V. You may need to change the display settings to be able to clearly see the waveform. Figure 6.1 shows an example of the output you should expect to see.

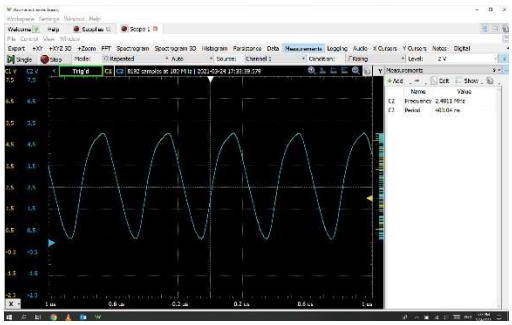

Figure 6.1. Sample output waveform.

9. Use the built-in measurements or the cursors to determine the period of the waveform.
10. Use the measured value of the period to calculate the average propagation delay of an inverter on the MC14007. To figure out how to do that, you'll need to understand why this circuit generates the oscillation. If you can't figure it out, search the term "ring oscillator" on the internet or look it up in any textbook on digital design.