ECEE 434 Lab 2 - Mosfet Inverter Propagation Delay

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Introduction & Background

Capacitance is an inherent property in transistors that can be used to determine other properties of the transistor. The experiment performed involved simulating a CMOS inverter and measuring the output to determine the propagation delay (t_{PHL} and t_{PLH}) of the circuit. This information was then used to determine the NMOS/PMOS equivalent resistance, and the Gate and Drain capacitances.

The lab required further use of Cadence Virtuoso to modify several parameters and components, and then build and simulate the circuits.

Procedure

This experiment consisted of four distinct but related parts.

1. Verifying the strength of an NMOS transistor with respect to a PMOS.
   - Simulate an inverter with matched PMOS/NMOS widths and measure the respective propagation delays.
   - t_p can be found with the above propagation delays, and R_n can be calculated.
2. Find R_N and R_P
   - Using a new circuit with different load capacitance, use propagation delays and approximating functions to find the resistance values.
3. Find C_D using some cool ass techniques.
   - boop!
4. Find C_G
   - More manipulation.

Results

Verify Strength of NMOS with respect to PMOS

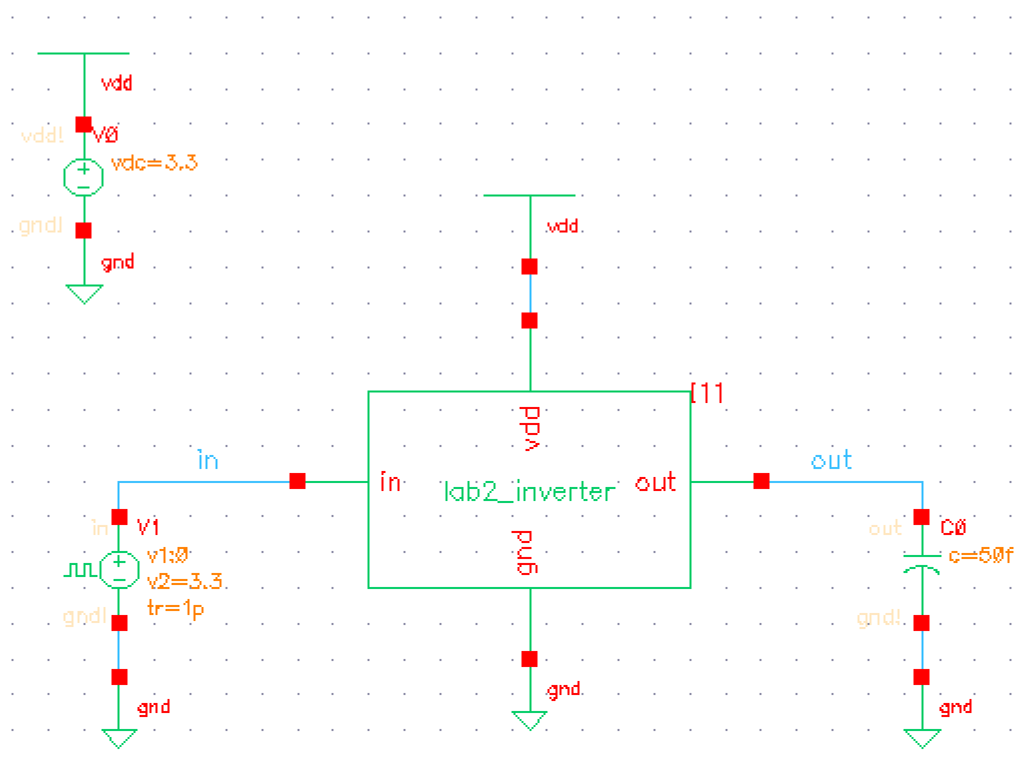

Figure 1: Schematic used for Part (1) PMOS vs. NMOS Strength

The values for t_{PLH} and t_{PHL} were measured from the output waveform of the simulation.

$t_{PLH} = 25.141ns - 20.001ns = 5.140ns$

$t_{PHL} = 30.07ns - 30.001ns = 0.069ns$

$\frac{k_N}{k_P} \approx \frac{t_{PLH}}{t_{PHL}} = \frac{5.140}{0.069} = 74.49$

The reason $\frac{k_N}{k_P} \approx \frac{t_{PLH}}{t_{PHL}}$ is because the ratio $\frac{k_N}{k_P} = \frac{\mu_N}{\mu_P}$, which is representative of the carrier mobility. The propagation delay is present in part because of the carrier mobility and recombination rate of the materials.

Find R_n

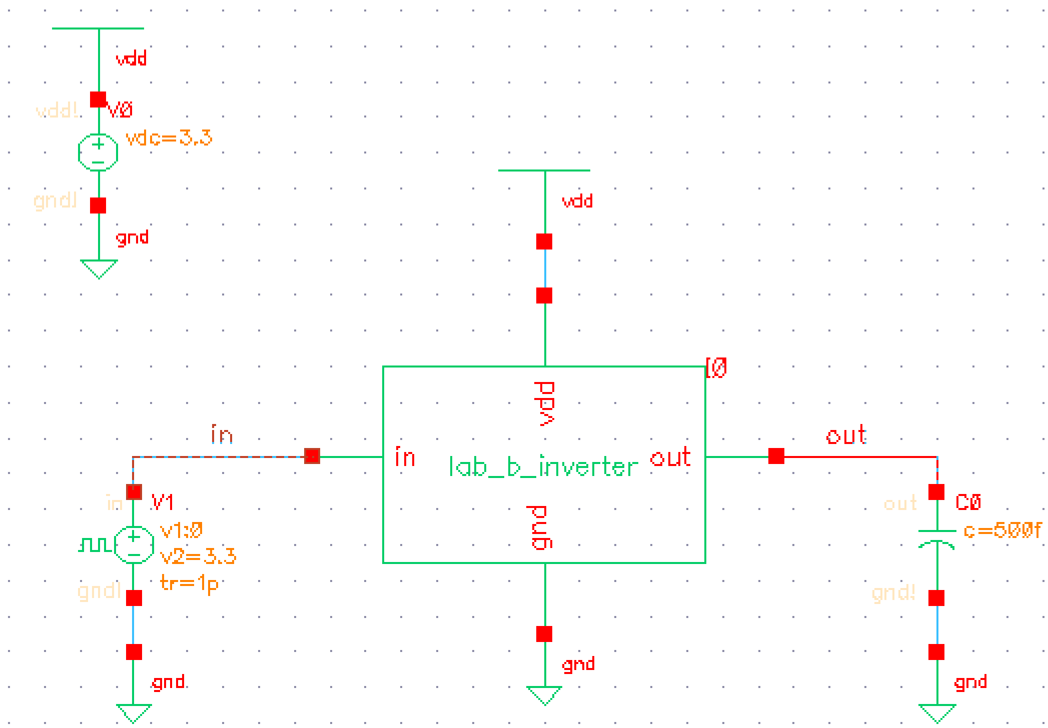

Figure 2: Schematic used to find R_N of the Inverter circuit.

R_n can be found by using the average resistance equation for finding t_{PHL}:

$$t_{PHL} = 0.69 * R_N * C_{load}$$

That function can be easily manipulated to find the R_N value. The capacitance value is equivalent to the load capacitor in the circuit which was 500fF.

$t_{PHL} = 103.7145ns - 100.0005ns = 3.714ns$

$R_N = \frac{t_{PHL}}{0.69 * C_{load}} = 10765.22\Omega$

$t_{PLH} = 56.6188ns - 50.0015ns = 6.6173ns$

$R_P = \frac{t_{PLH}}{0.69 * C_{load}} = 19180.58\Omega$

The time constant of an RC circuit is determined by $\tau = R_{eq}C_{eq}$. In this circuit, the high to low and low to high propagation delays are measured at half of the transition between the two states. This corresponds to a multiplication by 0.69 (half-time). Using this knowledge, the equivalent resistance of the MOSFET can be calculated.

Find C_D

$t_{PLH} = 50.1026ns - 50.0015ns =$

$t_{PHL} = 100.0592ns - 100.0005ns =$

Find C_G

$t_{PLH} = 54.3188ns - 50.0016ns =$

$t_{PHL} = 103.0953ns - 100.0004ns =$

Conclusion

Things to say:

- we found how to use propagation delays to determine certain aspects of
- these results, while not necessarily entirely accurate, help describe in general the behavior of the circuit.