Fall 2013 **Introduction to VLSI Design**

Lab Assignment #4

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1 Objective

The objective of this laboratory is to understand the effect of `Inverter` sizing on propagation delay and the design of a `Ring Oscillator`. The laboratory tasks are:

- Sizing a chain of `Inverters`;
- Design a `Ring Oscillator`.

2 Assignments

An `Inverter Chain` and a `Ring Oscillator` are designed in this laboratory.

2.1 Sizing an `Inverter Chain`

The `Inverter Chain` consists of a row of `Inverters`, and is used to find the propagation delay of an `Inverter`:

1. Compute the optimal number of `Inverters` that leads to a minimum propagation delay from input to output in an `Inverter Chain` (Set the input capacitance to 10fF, and the output capacitance to 1pF);
2. Simulate the `Inverter Chain` to observe the propagation delay
   Input pulse parameters:
   - period: 200ns,
   - rise time: 10ns,
   - fall time: 10ns;
3. Compute the average propagation delay of each `Inverter` and compare the average propagation delay with the propagation delay simulated in Laboratory #2;
4. Increase the size of each `Inverter` from 1.5um to 5um and calculate the propagation delay for each `Inverter` size.

2.2 Ring Oscillator

The `Ring Oscillator` can be used to generate square waves in digital circuits. The tasks in this assignment are:

1. Design a `Ring Oscillator` with 21 `Inverters`;
2. Simulate the `Ring Oscillator`;
3. Observe the propagation delay from input to output.

2.3 Hand in Report(Due next Wednesday!)

Lab reports are due next Wednesday before the class. Unless explicitly stated, lab reports are typically due one week after the Wednesday laboratory session. **Electronic submission in pdf or doc format through email** is accepted.

The report on this laboratory should include the following:

1. `Inverter Chain`:
   - Calculate the optimal number of `Inverters` in a chain. Simply explain how you calculate the optimal number of `Inverters`.;
   - The schematic view of the `Inverter Chain`;
   - The simulation waveform with markers delineating the propagation delay t_p time;
   - Compute the average propagation dalay of each `Inverter`. Compare the average propagation delay with the propagation delay simulated in Laboratory #2;
   - Increase the size of the `Inverters` from 1.5um to 5.0um with a step of 0.2um, and plot the change in propagation delay as a function of the size of the `Inverters`.
2. Ring Oscillator:
   - The schematic view of `Ring Oscillator`;
   - The simulation result of the waveform generated by the ring oscillator.
   - Mark the simulation result to indicate the clock period of the generated waveform.