

**Laboratory Goals**

- ❑ Design and construct a CMOS Inverter using CMOS Transistors
- ❑ Measure propagation delay of Inverter with comparison to IC Inverter

**Pre-lab reading**

- ❑ *Student Reference Manual for Electronic Instrumentation Laboratories* by Stanley Wolf and Richard Smith, Copyright 1990.
- ❑ *Analysis and Design of Digital Integrated Circuits* published by McGraw-Hill, Copyright 2004.(Chapter 4)
- ❑ *CMOS Electronics, How it works, How it fails* published by Wiley-Interscience, Copyright 2004.
- ❑ *P-Channel enhancement mode vertical D-MOS transistor* published by Philips Semiconductor, Copyright 1995
- ❑ *N-Channel enhancement mode Field Effect Transistor* published by Fairchild Semiconductor, Copyright 1995

**Equipment needed**

- ❑ Lab notebook, pen
- ❑ Agilent 54622 Digital Oscilloscope
- ❑ 2 oscilloscope probes (attached to the oscilloscope)
- ❑ Agilent 33120A Function Generator
- ❑ 1 BNC/EZ Hook test lead

**Parts needed**

- ❑ Circuit breadboard
- ❑ Lab parts kit
- ❑ Transistor, P-MOS, BS250
- ❑ Transistor, N-MOS, BS170
- ❑ Jumper wires
- ❑ 7404 Inverter Chip

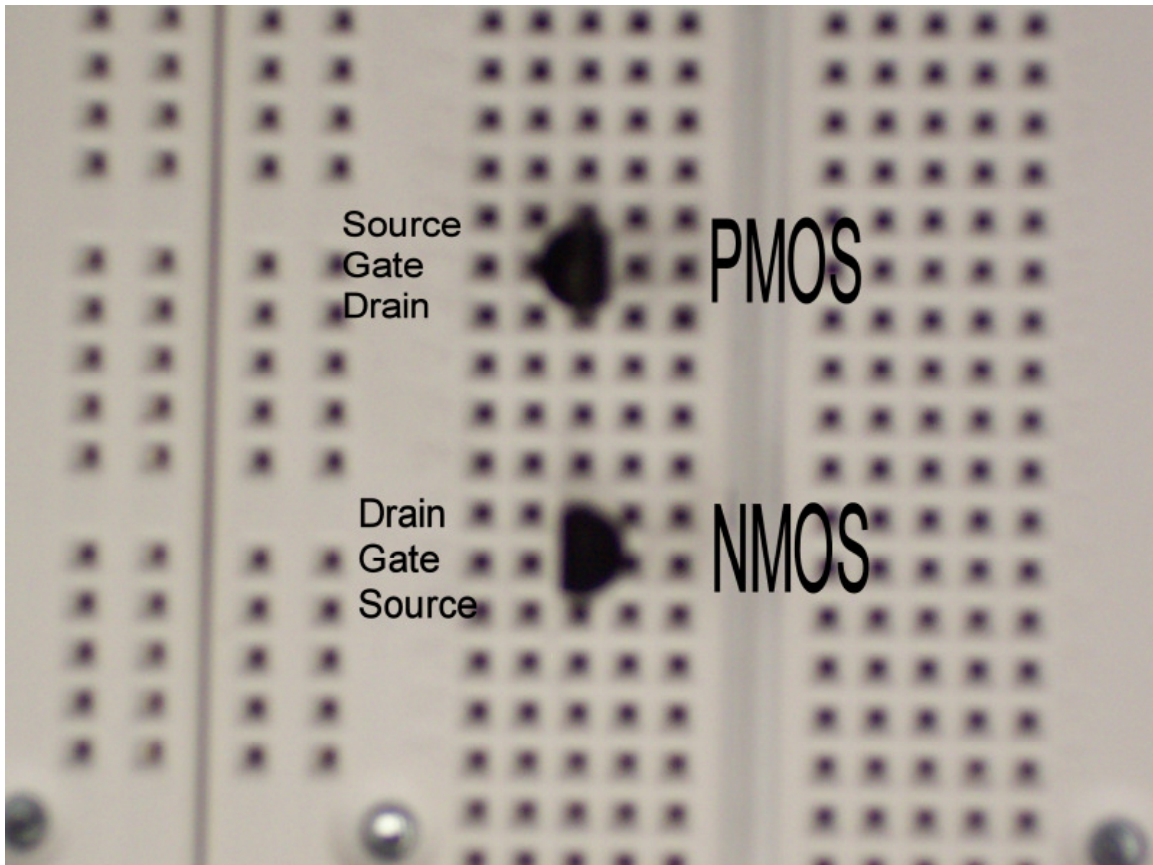
**Lab safety concerns**

- ❑ Make sure all circuit connections are correct, and no shorted wires exist
- ❑ Adjust signal generator to the proper level before connecting it to the circuit
- ❑ Transistors maybe extremely hot after lab handle with care

## 1. Pre-Lab Inverter Design

- ❑ Draw a schematic within PSPICE of an Inverter for layout purposes (Labeling the gate, source, and drain nodes)
- ❑ Create the truth table for an Inverter

## 2. Circuit Construction and Signal Measurement



Inverter Layout

- ❑ Build the circuit you created from your Pre-Lab and show it to your TA
- ❑ Turn the oscilloscope on
- ❑ Turn the function generator on
- ❑ Connect the BNC/EZ test lead between the generator output and the gate input of the Inverter and ground respectively
- ❑ Adjust the generator to output a 5 Vpp square wave offset by 2.5 V
- ❑ Check Sys Menu, Out Term is set to *HIGH Z* not *50 OHM*
  
- ❑ Clip the **CH1** oscilloscope probe and ground clip to the circuit input and ground respectively

- ❑ Clip the **CH2** oscilloscope probe and ground clip to the circuit output ( $V_{out}$ ) and ground respectively
- ❑ Measure and record the circuit propagation delay
- ❑ Repeat Steps for IC Inverter (7404 Inverter Chip)

### 3. Analysis

Write a summary report for this lab. Be sure to also include the following topics:

What is the difference between the IC inverter propagation delay and the constructed inverter propagation delay? What reasons can you give for the difference, if any?

What applications can you think of for this circuit?

Explain any difficulties you had with this lab. (Please include suggestions to improve the lab, if you have them).

#### Clean up

Before leaving the lab, take a few minutes to make sure all equipment and test leads are returned to your cabinet, and then lock it. Return the cabinet key to your T.A. Pick up any loose parts on the workstation table, and wipe off any eraser shavings, or other debris with a paper towel. Dispose of the paper towel and debris in the wastebasket.