University of Pennsylvania
Department of Electrical and System Engineering
Circuit-Level Modeling, Design, and Optimization for Digital Systems

ESE370, Fall 2021 — Inductive Noise and Crosstalk — Sunday, November 21

In Detkin Lab: Monday, November 22, 12:00PM
Due: Handin will be part of HW8
NOTE: For help capturing data and screenshots from the oscilloscope see:
`https://www.youtube.com/watch?v=YoXMoZSuXpU`

- You will work in teams of two, where each of you will do individual parts A or B at different lab stations, and then demo your part to your teammate. You should also share any data collected with your teammate after the lab.

	A	B		A	B
Team 1	Ryan	Sheon	Team 6	Zach	Andrew
Team 2	Shane	Brendan	Team 7	Beth	Nick
Team 3	Noam	Esther	Team 8	Sadek	Lloyd
Team 4	Arda	Naveen	Team 9	Adi	Konstantinos
Team 5	Nathan	Rafael			

1. **Part A: Inductive Noise** Observe and measure switching dynamics for the following cases of switching for a 74HC04 (6 inverters with one power and ground pad in a 14 pin package). Pinout for IC is at end of lab handout. Drive an input with a 5 V_{pp} 1MHz square wave from the function generator. Use 5V supply and square wave inputs. Set your scope to view the input, output, and Vdd simultaneously, and make sure you set scope triggering on the input signal. Use a non-polarized capacitor greater than 0.1μF. 1μF capacitors are available from the instructor.

   - PC Board with 74HC04. Get part from instructor. Note the DIP socket has 16 pins. The two extra sockets on the top of the chip are tied to GND and Vdd (from left to right) respectively to allow you to insert the bypass capacitor easily.
     * DIP IC on PC board with no bypass capacitor
     * DIP IC on PC board with bypass capacitor

For each case:

- Observe the output **data** signal from the DIP
  - What is the magnitude of the "unintended" ringing?
  - How long does the signal take to settle within 10% of its intended final value? (for both rise and fall)
- Observe the **power and ground pins** while the component is operating.
  - How far from the steady-state value does the power rise and/or fall?
  - Over what period of time does the disturbance occur.

2. **Part B: Crosstalk** Observe and measure crosstalk. With the function generator drive one wire and observe the impact on another wire. How large is the voltage swing on the observed wire? You may need to adjust the V/div to see the voltage swing.
   - Use PCB trace with 4 different trace wire lengths corresponding to wavelength ratios–full wavelength, 3/4 wavelength, 1/2 wavelength and 1/4 wavelength. .For each of the 3 PCB trace wire lengths ($3/4\lambda$, $1/2\lambda$, $1/4\lambda$), drive wire A and measure:

     - B with B and C undriven/floating
     - C with B and C undriven/floating
     - B with B grounded
     - C undriven/floating with B grounded
3. Demo your part to your teammate and discuss the below questions to be turned in with HW 8.

- **After Lab: This will be part of HW8 and is here for context for the data.**

1. Summarize raw data collected in lab. Describe your observations (each answer should be 2–3 sentences; most answers must be qualitative, but one or two of these might benefit from an equation).
   - Impact of bypass capacitors?
   - Impact of crosstalk on driven vs. undriven signals?
   - Impact of wire length on signal crosstalk?

   The observations and insight should come out of your team data collection and discussion. Nonetheless, this writeup for HW8 should be done independently and expressed in your individual words.

Pinout for 74HC04: