Computer Systems and Organization 1

Warm up!
Can I make an n-input AND
from 2-input AND gates?

Warm up!
What about XOR gates?

adders, clocks

CS 2130: Computer Systems and Organization 1
January 30, 2026

Announcements

- Homework 1 due Monday

Our story so far

- Transistors
- Information modeled by voltage through wires (1 vs 0)
- Gates: `&` `|` `~` `^`
  - Operate on 1-bit input producing 1-bit output
- Multi-bit values: representing integers
  - Signed and unsigned
  - **Bitwise operations** on them as bit vectors
- Floating point

Multi-bit Calculations

How to do the *work* of multi-bit?

Things like...

- Add integers to get integer answers

Adder

Add 2 1-bit numbers: a, b

Adder

Can we use this in parallel to add multi-bit numbers?

Adder

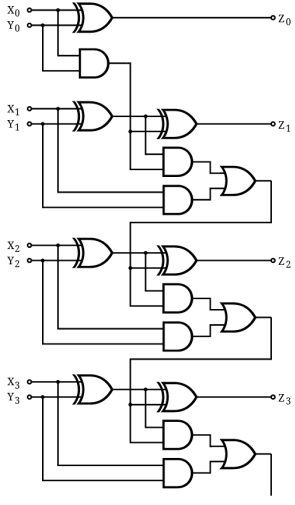
Can we use this in parallel to add multi-bit numbers? What is missing? Consider:

$$\begin{array}{r} 11 \\ +01 \\ \hline \end{array}$$

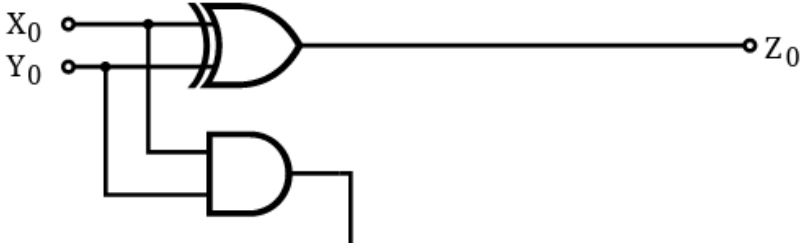
3-input Adder

Add 3 1-bit numbers: a, b, c

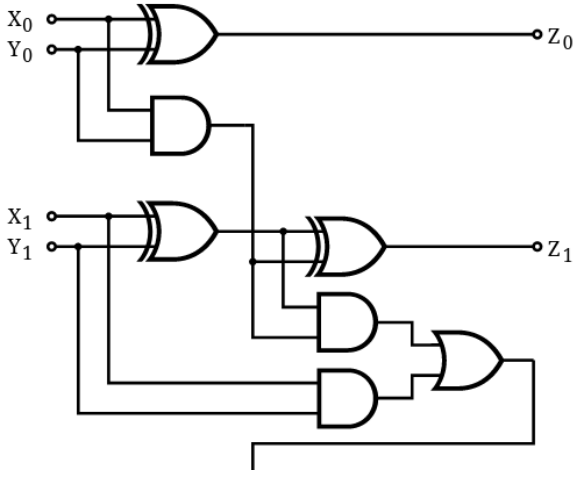
Ripple-Carry Adder



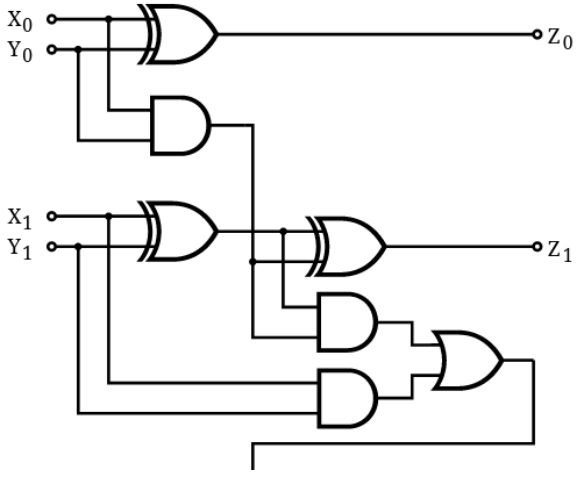
Ripple-Carry Adder: Lowest-order Bit



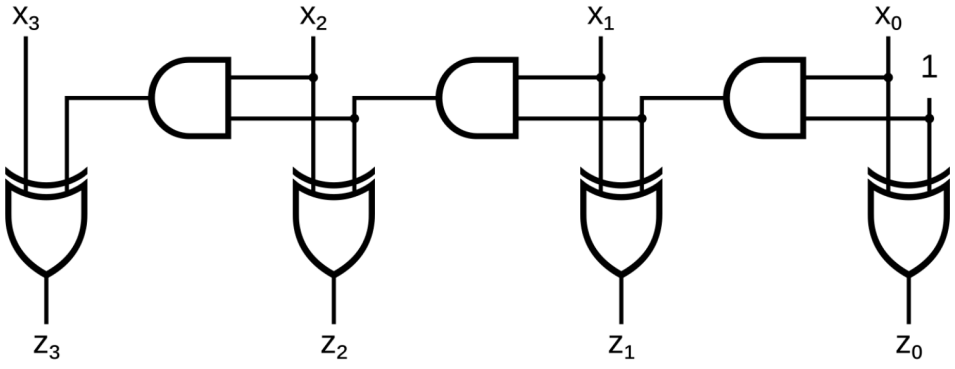
Ripple-Carry Adder: In General



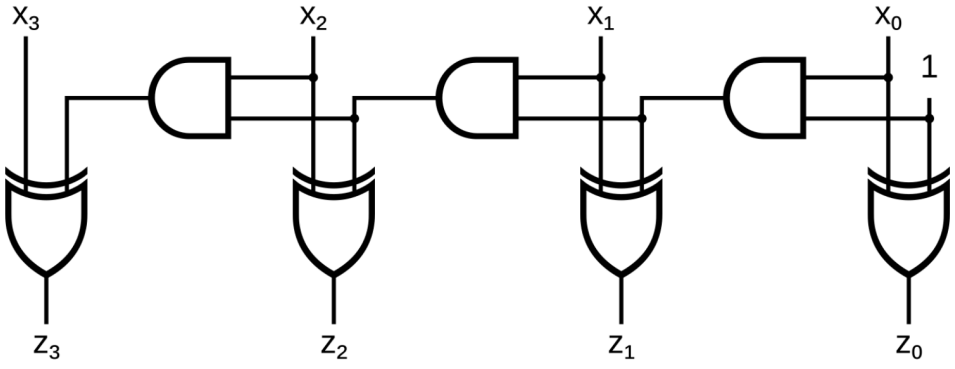
Ripple-Carry Adder: In General



What does this circuit do?

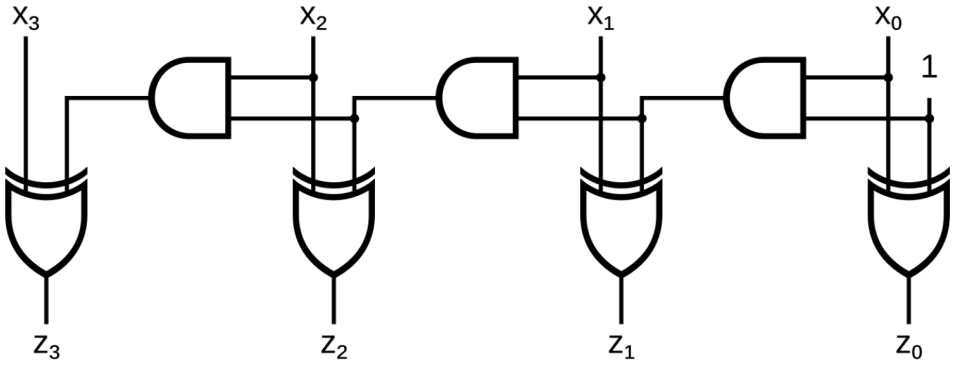


Increment Circuit



Building a Counter

Building a Counter

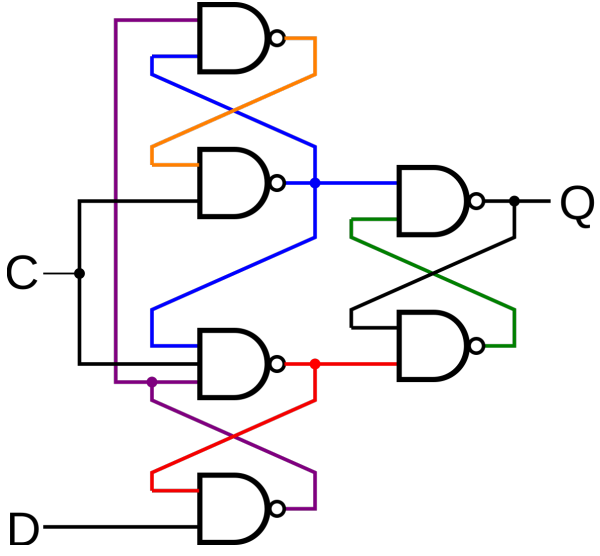


Gate Delay

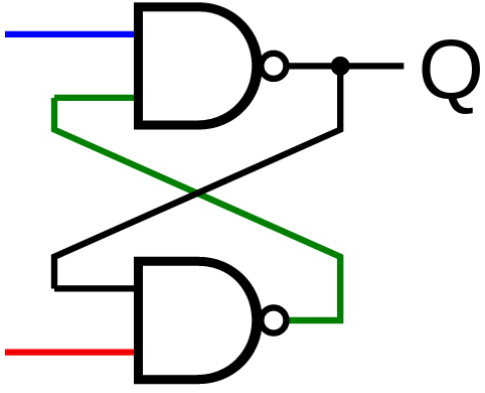
What happens when I change my input?

Building a Counter - Waiting

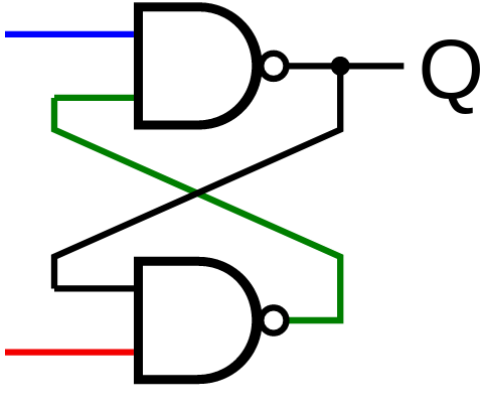
1-bit Register Circuit



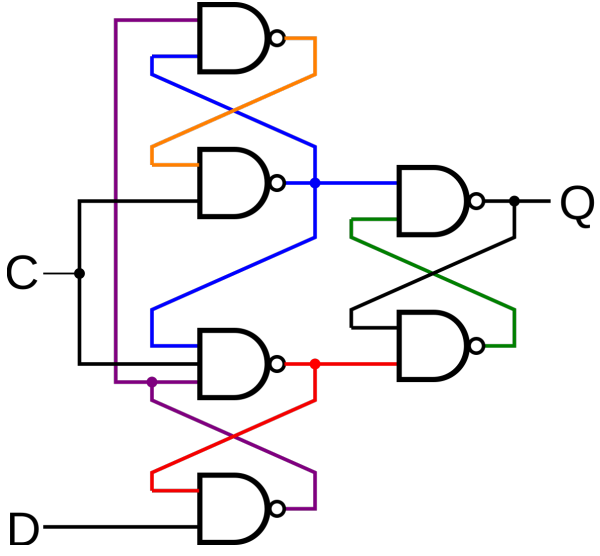
1-bit Register Circuit



1-bit Register Circuit

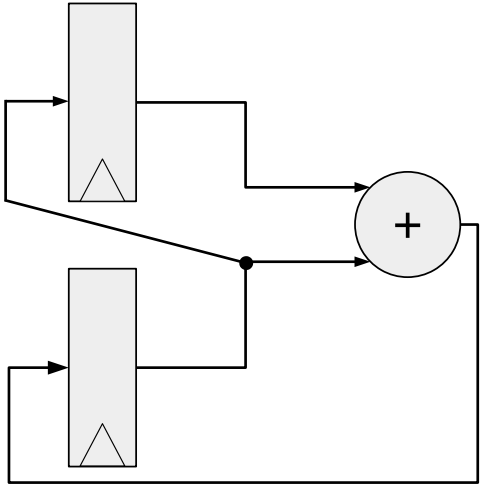


1-bit Register Circuit



Building a Counter

Another Circuit



Another Circuit