More bits, circuits, adders (From the last class)

CS 2130: Computer Systems and Organization 1

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Announcements

- Quiz 2 out later today, due Sunday at 11:59pm
- Homework 1 due Monday
- Homework 2 available Monday

Adder

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

What is missing?

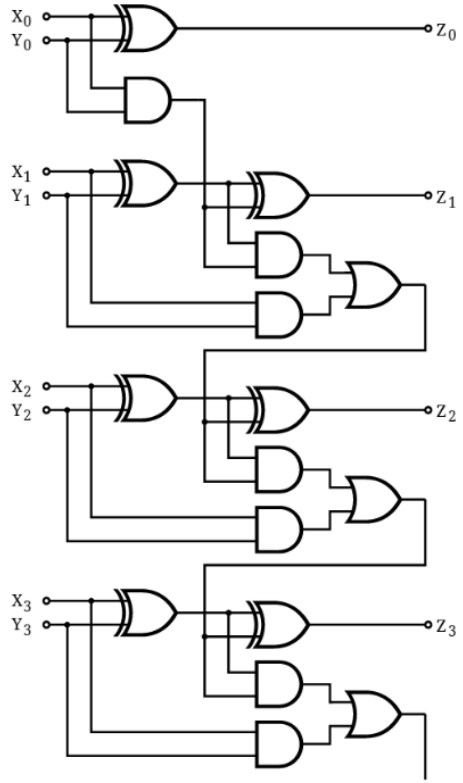
Consider:

```
  11
+01
----
```

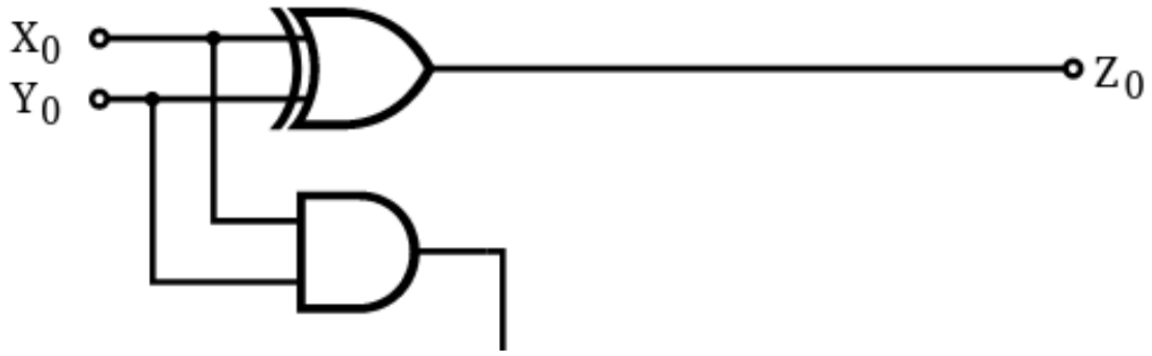
3-input Adder

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

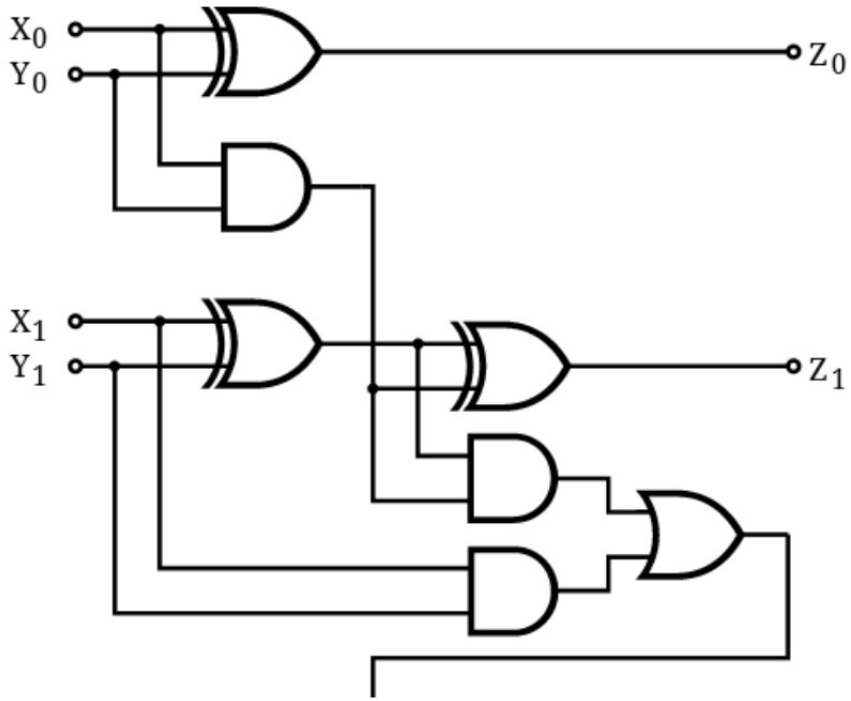
Ripple-Carry Adder



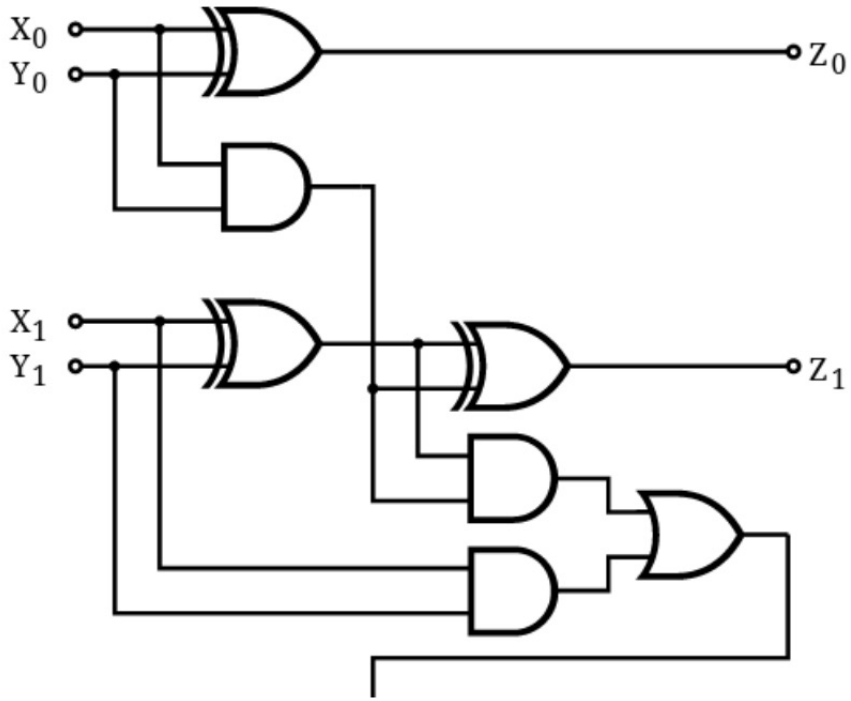
Ripple-Carry Adder: Lowest-order Bit



Ripple-Carry Adder: In General



Ripple-Carry Adder: In General



Clocks, Registers

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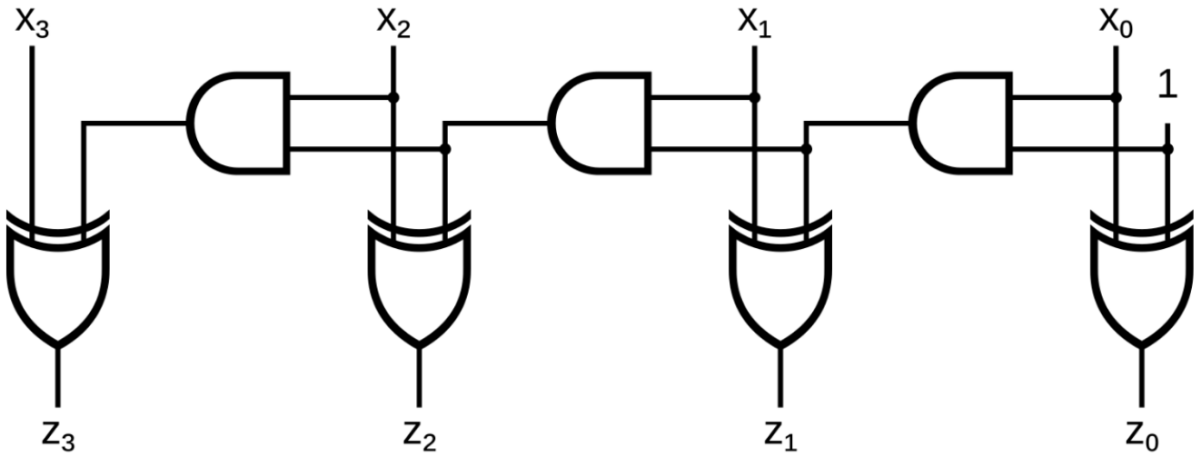
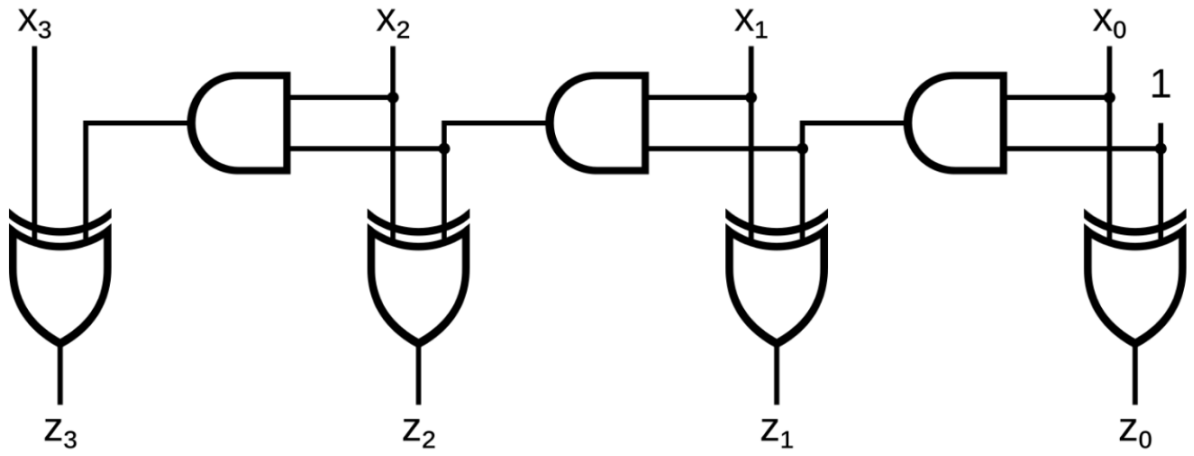
What does this circuit do?

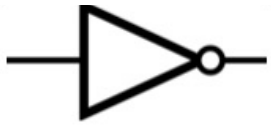


Increment Circuit



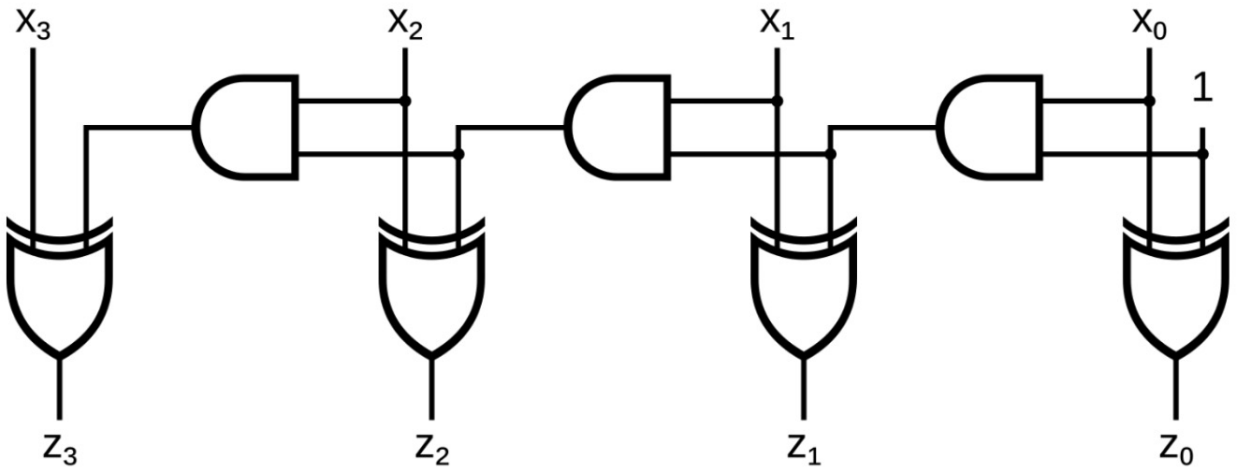
Gate Delay

What happens when I change my input?



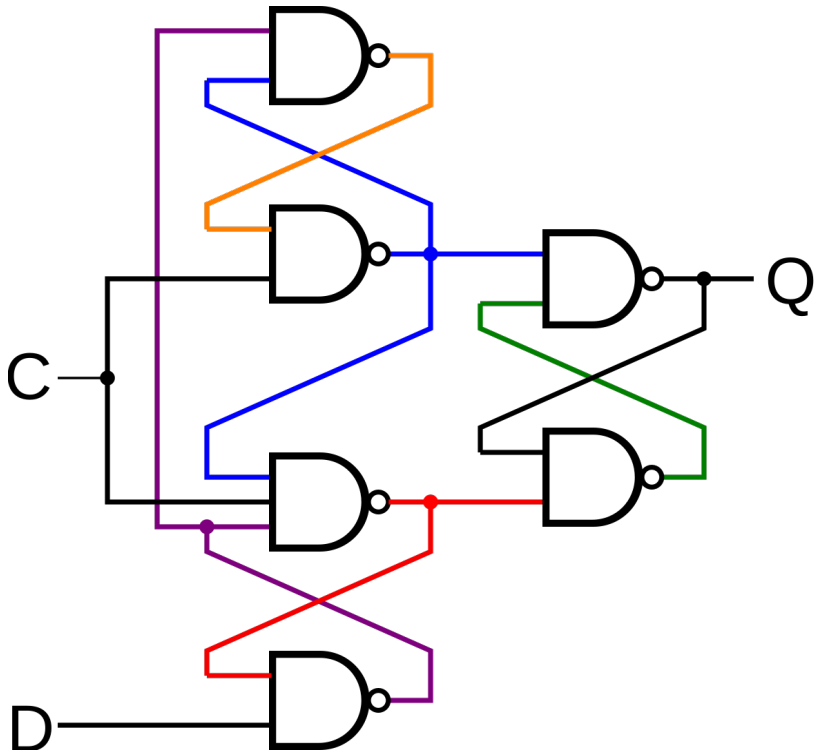
Building a Counter

Building a Counter

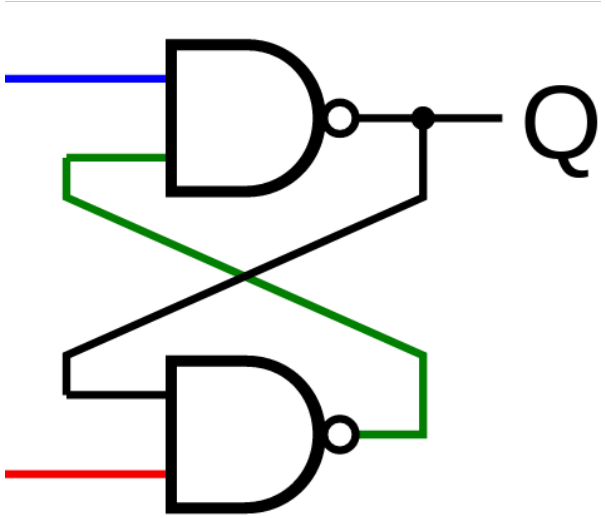


Building a Counter - Waiting

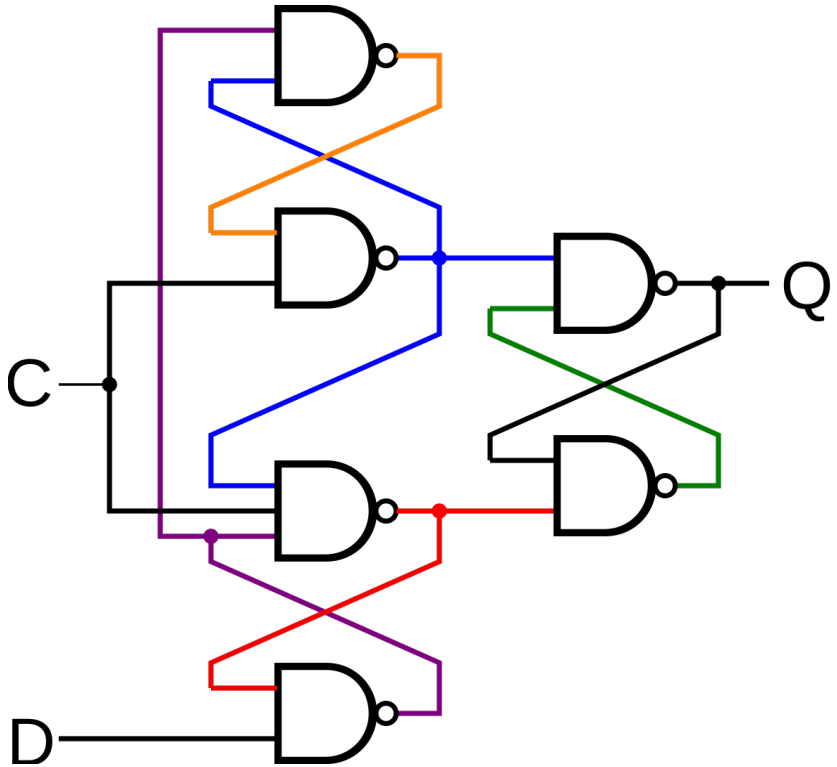
1-bit Register Circuit



1-bit Register Circuit

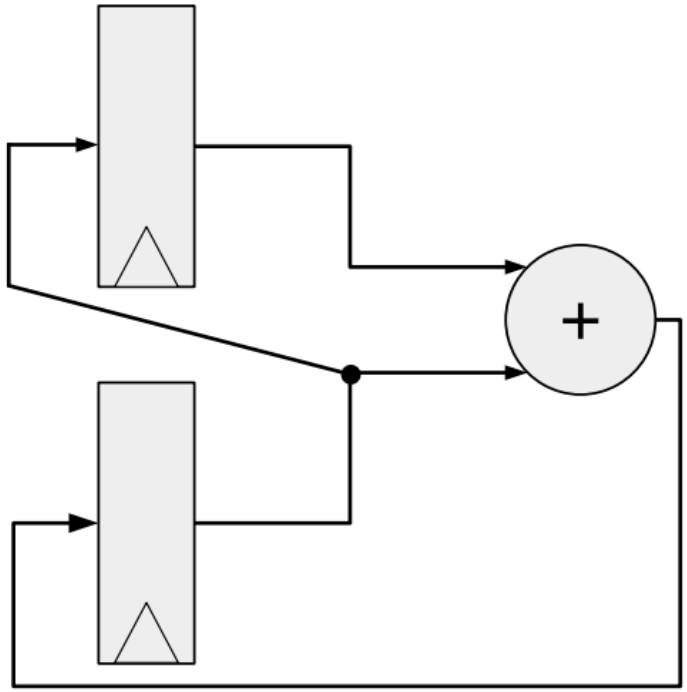


1-bit Register Circuit

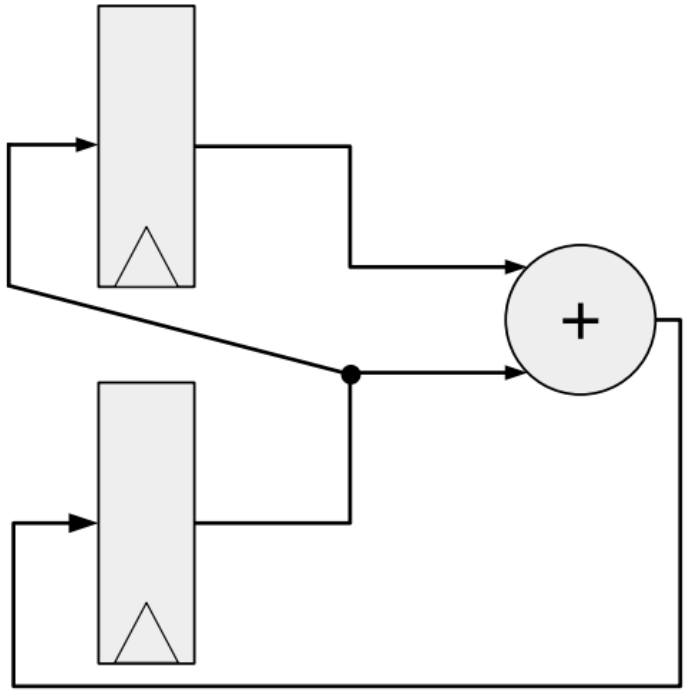


Building a Counter

Another Counter



Another Counter



Common Model in Computers

Code to Build Circuits from Gates

Write code to build circuits from gates

- Gates we already know: &, |, ^, ~
- Operations we can build from gates: +, -
- Others we can build:

Code to Build Circuits from Gates

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- Gates we already know: &, |, ^, ~
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- Ternary operator: ? :

Equals

Equals: =

- Attach with a wire (i.e., connect things)
- Ex: z = x * y

Equals

Equals: =

- Attach with a wire (i.e., connect things)
- Ex: z = x * y
- What about the following?

  x = 1

  x = 0

Equals

Equals: =

- Attach with a wire (i.e., connect things)
- Ex: z = x * y
- What about the following?

  x = 1

  x = 0
- **Single assignment:** each variable can only be assigned a value once

Any Questions?