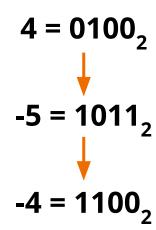
# **Bits of Architecture**

Integer Arithmetic Basics

# **Negation**

#### **Negation**

- Two steps
  - Flip all the bits
  - Add 1



#### **Negation**

- Why does this work?
- We want the positive and negative of a number to add up to 2<sup>N</sup>
  - Radix Complement
  - Two's-Complement
- Flipping the bits gets us one away
  - Adding 1 gets us the rest of the way

| Binary | Unsigned | Signed |
|--------|----------|--------|
| 000    | 0        | 0      |
| 001    | 1        | 1      |
| 010    | 2        | 2      |
| 011    | 3        | 3      |
| 100    | 4        | -4     |
| 101    | 5        | -3     |
| 110    | 6        | -2     |
| 111    | 7        | -1     |

## **Sign Extension**

#### **Sign Extension**

- How do we extend the number of bits of a signed number?
  - Simply copy the sign bit
- Why does this work?

# **Positive Numbers**

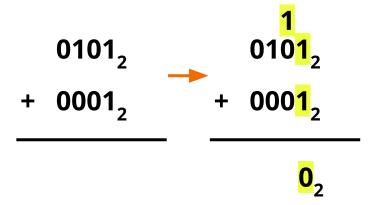
$$4 = 0100_{2}$$

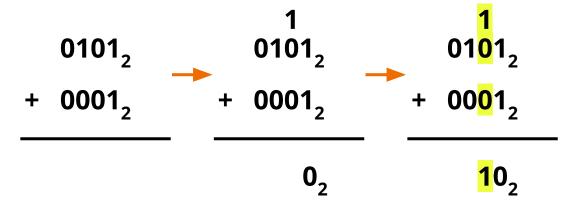
$$4 = 00100_2$$

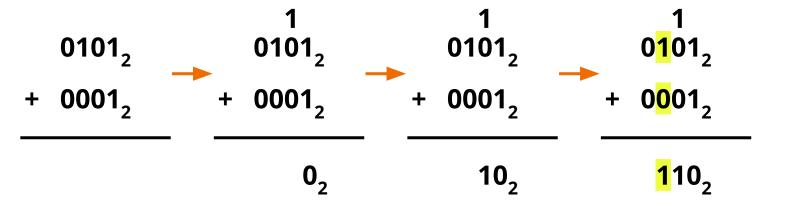
# **Negative Numbers**

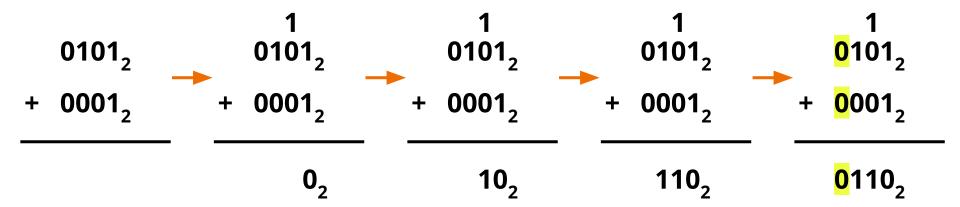
$$-8 = 11000_{2}$$

## **How Do We Add Binary Numbers?**

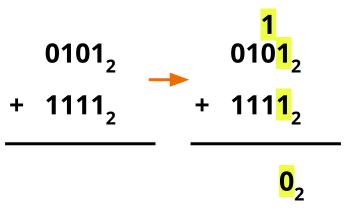


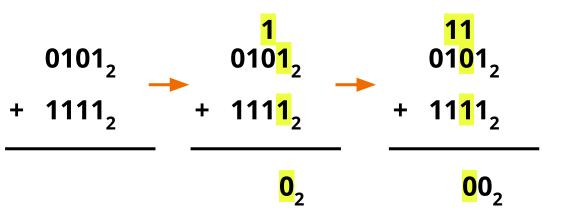


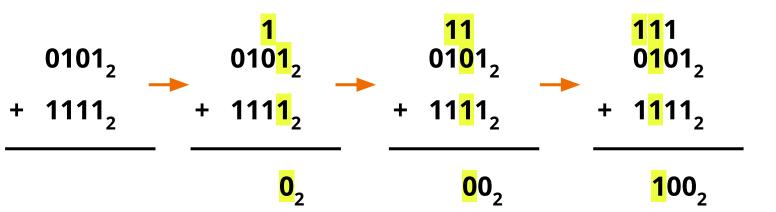


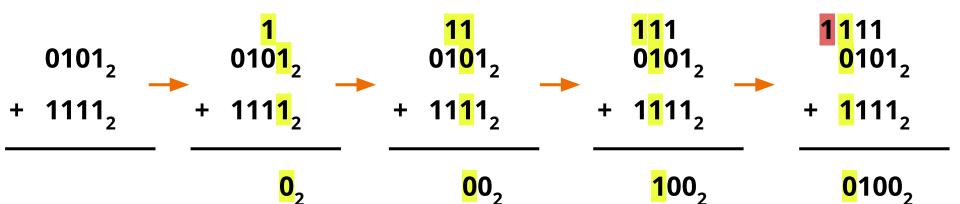


## **Can We Add Positives and Negatives?**









## **Important Considerations**

#### **Bit Limitations**

- Can we add -4 and -4 and get the desired result?
  - In 4 bits yes!
  - In 3 bits no!
- Can the product of two 4-bit numbers fit in 4-bits?
  - Often times not