

## 1.2 BOOLEAN ARITHMETIC

### Binary Addition

#### Rules of Binary Addition

##### ✓ Binary Addition

##### ✓ Rules of Binary Addition

- $0 + 0 = 0$
- $0 + 1 = 1$
- $1 + 0 = 1$
- $1 + 1 = 0$ , and carry 1 to the next more significant bit

##### ✓ Example

$$00011010 + 00001100 = 00100110$$

$$\begin{array}{r}
 \phantom{00}11 \\
 00011010 \\
 + 00001100 \\
 \hline
 00100110
 \end{array}$$

Note: The rules of binary addition (without carries) are the same as the truths of the XOR gate.

### Binary Subtraction

#### Rules of Binary Subtraction

$$0 - 0 = 0$$

$$0 - 1 = 1, \text{ and borrow 1 from the next more significant bit}$$

$$1 - 0 = 1$$

$$1 - 1 = 0$$

##### Example

$$00100101 - 00010001 = 00010100$$

$$\begin{array}{r}
 00100101 \\
 + 00010001 \\
 \hline
 00010100
 \end{array}$$

## Binary Multiplication

### Rules of Binary Multiplication

$$0 \times 0 = 0$$

$$0 \times 1 = 0$$

$$1 \times 0 = 0$$

$$1 \times 1 = 1, \text{ and no carry or borrow bits}$$

### Example

$$\begin{array}{r}
 00101001 \times 00000110 = \\
 \quad 11110110 \\
 \begin{array}{r}
 00101001 \\
 \times 00000110 \\
 \hline
 00000000 \\
 00101001 \\
 01010010 \\
 \hline
 011110110
 \end{array}
 \end{array}$$

Note: The rules of binary multiplication are the same as the truths of the AND gate.

## Binary Division

Binary division is the repeated process of subtraction, just as in decimal division.

$$\text{Example 1: } 00101010 \div 00000110 = 00000111$$

$$00101010 \div 00000110$$

$$= 00000111$$

$$111 = 7(\text{base } 10)$$

$$\begin{array}{r} 11000101010 \\ - 110 \\ \hline \end{array} = 42(\text{base } 10) - 6(\text{base } 10)$$

$$\begin{array}{r} 1 \\ 10101 \\ - 110 \\ \hline \end{array} \quad \text{borrows}$$

$$\begin{array}{r} 110 \\ - 110 \\ \hline 0 \end{array}$$

Example 2:  $10000111 \div 00000101 = 00011011$  1.3 1.4 1.5

$$\begin{array}{l} 10000111 \div 00000101 \\ = 00011011 \end{array}$$

$$11011 = 27(\text{base } 10)$$

$$\begin{array}{r} 10100111 \\ - 101 \\ \hline \end{array} = 135(\text{base } 10) - 5(\text{base } 10)$$

$$\begin{array}{r} 101 \\ - 101 \\ \hline \end{array}$$

$$\begin{array}{r} 11 \\ - 0 \\ \hline \end{array}$$

$$\begin{array}{r} 111 \\ - 101 \\ \hline \end{array}$$

$$\begin{array}{r} 101 \\ - 101 \\ \hline 0 \end{array}$$