University of Al-Mustaqbal
College of Science
Department f Medical Physics

Digital Electronic

Third stage

Binary Addition and Subtraction

Lecture Eight

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Binary Addition and Subtraction

Introduction

The binary number system is the fundamental way computers and digital systems represent data.
Addition and subtraction are essential operations that form the basis for more complex arithmetic operations like multiplication, division, and logical processing.

1. The Binary Number System

- The binary system uses only two digits: **0 and 1**.
- It is based on two states:
  - **0** represents OFF or low signal
  - **1** represents ON or high signal

Each binary digit (bit) represents a power of 2:

- 2^0 for the first digit
- 2^1 for the second digit
- 2^2 for the third digit
- and so on...

2. Binary Addition Rules

Binary addition is similar to decimal addition but simpler. There are only four cases:

Operation	Result	Carry
0 + 0	**0**	**No carry**
0 + 1	**1**	**No carry**
1 + 0	**1**	**No carry**
1 + 1	**0**	**Carry 1**

Operation	Result	Carry
• 1 + 1	10	(write down 0, carry over 1)
1 + 1 + 1	11	(write down 1, carry over 1

Examples of Binary Addition

Example 1: 101 + 11

```
 101
+  11
------
 1000
```

Explanation: 1+1=10 (write 0, carry 1), 0+1+1=10 (write 0, carry 1), 1+1=10 (write 10)

Example 2: 1101 + 1011

```
 1101
+ 1011
------
 11000
```

Explanation: 1+1=10 (write 0, carry 1), 0+1+1=10 (write 0, carry 1), 1+0+1=10 (write 0, carry 1), 1+1+1=11 (write 11)

Example 3: 111 + 101

```
 111
+ 101
------
 1100
```

Explanation: 1+1=10 (write 0, carry 1), 1+0+1=10 (write 0, carry 1), 1+1+1=11 (write 11)

Example 4: 1010 + 110

```
 1010
+  110
------
 10000
```

Explanation: 0+0=0, 1+1=10 (write 0, carry 1), 0+1+1=10 (write 0, carry 1), 1+1=10 (write 10)

Example 5: 1111 + 1

```
 1111
+    1
------
 10000
```

Explanation: 1+1=10 (write 0, carry 1), 1+1=10 (write 0, carry 1), 1+1=10 (write 0, carry 1), 1+1=10 (write 10)

Example 6: 1011 + 0101

```
  1011
+ 0101
--------
10000
```

Explanation:1 + 1 = 0 with a carry of 1 **,** 1 + 0 + 1(carry) = 0 with a carry **,**

0+ 1 + 1(carry) = 0 with a carry ,1 + 0 + 1(carry) = 0 with a carry Write the final carry → result is **10000**

3. Binary Subtraction Rules

Binary subtraction also has four basic cases:

Operation	Result	Borrow
0 − 0	**0**	**No borrow**
1 − 0	**1**	**No borrow**
1 − 1	**0**	**No borrow**
0 − 1	**1**	**Borrow from next digit (0 - 1 = 1 (with a borrow of 1 from the next higher bit)**

When borrowing:

- 0 becomes 10 (binary)
- 10 − 1 = 1

Examples of Binary Subtraction

Example 1: 101 - 11

```
 101
-  11
------
  10
```

Explanation: 1-1=0, 0-1=1 (after borrowing), 0-0=0

Example 2: 1101 - 1011

```
 1101
- 1011
------
  10
```

Explanation: 1-1=0, 0-1=1 (after borrowing), 1-0=1, 0-1=1 (after borrowing)

Example 3: 111 - 101

```
  111
- 101
------
   10
```

Explanation: 1-1=0, 1-0=1, 1-1=0

Example 4: 1010 - 110

```
  1010
-  110
------
   100
```

Explanation: 0-0=0, 1-1=0, 0-1=1 (after borrowing), 0-0=0

Example 5: 10000 - 1

```
 10000
-    1
------
 1111
```

Explanation: Chain of borrows: 0-1=1 (borrow until we get 1 that can be reduced to 0)

Example 6: 10101 − 00111

10101

- 00111

01110

Explanation: 1 − 1 = 0 , 0 − 1 → borrow → becomes 10 − 1 = 1

- Next digit becomes 0 due to borrowing
- 0 − 1 → borrow → 10 − 1 = 1
- 0 (after borrow) − 0 = 0
- 1 − 0 = 1

Result: **01110**

4. Practical Applications

- ALU design in microprocessors
- Building Half Adders and Full Adders
- Register operations
- Implementing multipliers and dividers
- Programming microcontrollers and digital circuits

5. Practice Problems

1. **Addition:**

   1101 + 1011 = ?
2. **Subtraction:**

   10000 − 00101 = ?