Module A.4 – Binary Numbers

**Level 1: Presentation Notes**

1. Number systems used in Computer Science

a. List the main features of the Decimal System

* Decimal System
* Digits: 0,1,2,3,4,5,6,7,8,9

Used for communicating with human users

b. List the main features of the Binary System

Binary System (Base 2)

* Digits: 0,1 (On or Off)
* Binary 10 == Decimal 2
* Used by internal CPU and Memory circuits

c. List the main features of the Octal System

* Octal System (Base 8)
* Digits: 0,1,2,3,4,5,6,7 (No digits 8 & 9)
* Octal 10 == Decimal 8
* Used by Computer Scientists for groupings of 3 binary digits

d. List the main features of the Hexadecimal System

* Hexadecimal System (Base 16)
* Digits: 0,1,2,3,4,5,6,7,8,9, A, B, C, D, E, F (Uses extra letters)
* Hex F == Decimal 15
* Hex 10 == Decimal 16
* Used by Computer Scientists for groupings of 4 binary digits

2. Compare and contrast the Decimal and Binary systems

|  |  |  |
| --- | --- | --- |
| **Criteria** | **Decimal System** | **Binary System** |
| Digits  Used | Uses Digits:  0, 1, 2, 3, 4, 5, 6, 7 , 8, 9 | Uses Digits:  0, 1 (True, False) (+, -) |
| Addition Example | 0 + 1 = 1  1 + 1 = 2  9 + 1 = 10 | 0 + 1 = 1  1 + 1 = 10  11 + 1 = 100 |
| Powers of  Base | 100 = 1  101 = 10  102 = 100 | 20 = 1  21 = 10 (or 2 decimal)  22 = 100 (or 4 decimal) |
| Value of  111 | 111 = 102 + 101 + 100  (100 + 10 + 1) | 111 = 22 + 21 + 20  (Decimal : 4 + 2 + 1 = 7) |

3. Convert the following binary numbers to decimal:

1. 11 binary = 3
2. 101 binary = 4 + 1 = 5
3. 1010 binary = 8 + 2 = 10

4. Convert the following decimal numbers to binary:

1. 6 decimal = 110
2. 13 decimal = 101

5. Add the following binary numbers. (verify your answers using decimal)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| a) | **0101** | **(decimal 5)** |  | b) | **0101** | **(decimal 5)** |
|  | **+ 0010** | **(decimal 2)** |  |  | **+ 1010** | **(decimal 10)** |
|  | 0111 |  |  |  | 1111 |  |
|  |  |  |  |  |  |  |
| c) | **0011** | **(decimal 3)** |  | d) | **0110** | **(decimal 6)** |
|  | **+ 0010** | **(decimal 2)** |  |  | **+ 0011** | **(decimal 3)** |
|  | 0101 |  |  |  | 1001 |  |

6. List the main features of the following Computer Memory Structures:

a. Bit

* 1 binary digit
* Used for Boolean data type
* Building Block for all computer data and memory

b. Byte

* 8 binary digits
* Largest value: 1111 1111 (28 – 1 = 255 Decimals)

Used for Char (character) data type

* 36 lower case letters + 36 uppercase letters +10 number symbols + punctuation marks equal about 200 distinct characters

c. Word

* 16 binary digits (2 bytes)
* Largest value: 1111 1111 1111 1111
* (216 – 1 = 65,536 Decimals)

d. Integer Data Type

* Is 1 Word (16 bits)
* But must represent both Positive (+) and Negative (-)
* Range: +32767 to -32768
* Larger or smaller numbers require a different data type

e. Double Word

* 32 binary digits (4 bytes or 2 words)
* Largest value: 232 – 1 = 4 billion approx)

**Level 2: Research Questions**

1. The Intel 8085 microprocessor was a first generation processor that was used in many early game systems and personal computers. Google “8085 microprocessor architecture” to answer these questions.

a. Year Introduced

1977

b. Size of data bus (in bits)

8-bit

c. Largest data number (in binary and decimal)

1111 1111 in binary, 255 decimals

d. Size of address bus (in bits)

16-bit

e. Largest memory address (in binary and decimal)

1111 1111 1111 1111 in binary, 65,535 in decimal.

2. The Intel 8086 microprocessor was the processor used in the first IBM PCs running the DOS operating system. Google “8086 microprocessor architecture” to answer these questions.

a. Year Introduced

1976

b. Size of data bus (in bits)

16

c. Largest data number (in decimal)

255

d. Size of address bus (in bits)

20

1. Largest memory address (in decimal)

65,535