University of Anbar
College of Engineering
Dept. of Electrical Engineering

Subject / Digital Techniques
Second Stage / 1st Semester
(2017 – 2018)

_____

Octal-to-Decimal Conversion:

An octal number can be easily converted to its decimal equivalent by multiplying each octal digit by its positional weight. For example:

$372_{(8)} = 3 \times 8^2 + 7 \times 8^1 + 2 \times 8^0$

$\quad = 3 \times 64 + 7 \times 8 + 2 \times 1 = 250_{(10)}$

Example: convert $24.6_{(8)}$ to its decimal equivalent.

$24.6_{(8)} = 2 \times 8^1 + 4 \times 8^0 + 6 \times 8^{-1}$

$\quad = 2 \times 8 + 4 \times 1 + 6 \times 0.125 = 20.75_{(10)}$

Decimal-to-Octal Conversion:

A decimal integer can be converted to octal by using the same repeated division method that have been used in the decimal-to-binary conversion, but with a division factor of 8 instead of 2. An example is shown below:

$$\frac{266}{8} = 33 + \text{Remainder } 2$$

$$\frac{33}{8} = 4 \quad + \text{Remainder } 1$$

$$\frac{4}{8} = 0 \quad + \text{Remainder } 4$$

$$266_{(10)} = 412_{(8)}$$

For decimal fractions, multiplying instead of dividing, writing the carry into the integers position. An example of this is to convert 0.23 into an octal fraction.

$0.23 \times 8 = 1.84 = 0.84 \quad$ with a carry of 1

$0.84 \times 8 = 6.72 = 0.72 \quad$ with a carry of 6

$0.72 \times 8 = 5.76 = 0.76 \quad$ with a carry of 5

University of Anbar
College of Engineering
Dept. of Electrical Engineering

Subject / Digital Techniques
Second Stage / 1st Semester
(2017 – 2018)

The process is terminated after three places; if more accuracy were required, we continue multiplying to obtain more octal digit.

Octal-to-Binary Conversion:

The primary advantage of the octal number system is the ease with which conversion can be made between binary and octal numbers. The conversion from octal to binary is performed by converting each octal digit to its 3-bit binary equivalent. The eight possible digits are converted as indicated in Table (2).

Table (2)

Octal No.	0	1	2	3	4	5	6	7
Binary Equivalent	000	001	010	011	100	101	110	111

For example, $472_{(8)}$ is converted to its binary equivalent as follows:-

$472_{(8)} = 100111010_{(2)}$

$$
\begin{array}{ccc}
4 & 7 & 2 \\
\downarrow & \downarrow & \downarrow \\
\mathbf{100} & \mathbf{111} & \mathbf{010}
\end{array}
$$

Example: convert $34.562_{(8)}$ to its binary equivalent.

$34.562_{(8)} = 011100.101110010_{(2)}$

$$
\begin{array}{ccccccc}
3 & 4 & . & 5 & 6 & 2 \\
\downarrow & \downarrow & & \downarrow & \downarrow & \downarrow \\
\mathbf{011} & \mathbf{100} & \mathbf{.} & \mathbf{101} & \mathbf{110} & \mathbf{010}
\end{array}
$$

Binary-to-Octal Conversion:

Converting from binary integers to octal integers is done by grouping the binary bits into groups of three bits starting at the LSB. Then each group is converted to its octal equivalent.

Example: convert $100111010_{(2)}$ to octal system.
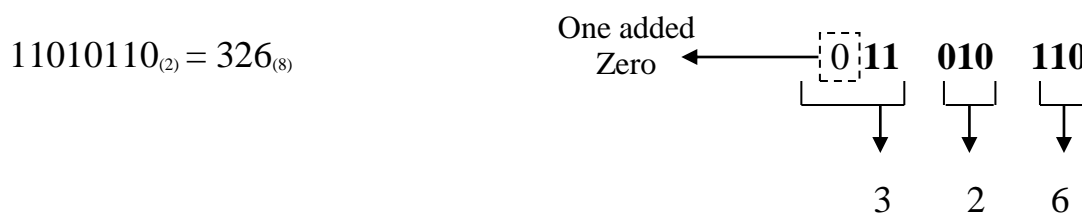
$100111010_{(2)} = 472_{(8)}$

8

$$
\begin{array}{ccc}
\mathbf{100} & \mathbf{111} & \mathbf{010} \\
\downarrow & \downarrow & \downarrow \\
4 & 7 & 2
\end{array}
$$

University of Anbar
College of Engineering
Dept. of Electrical Engineering

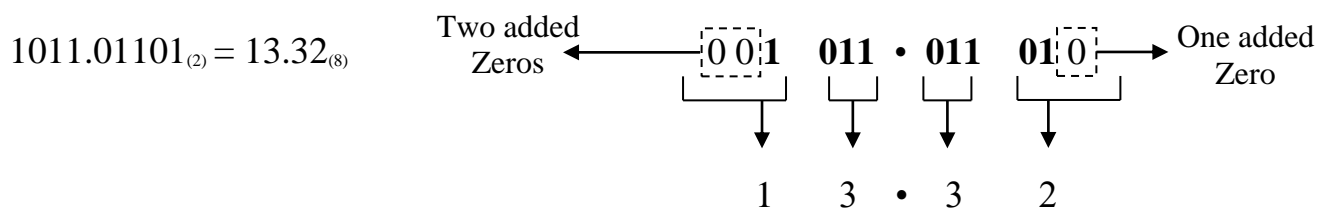*Subject / Digital Techniques*
Second Stage / 1st Semester
(2017 – 2018)

_____

Example: convert $11010110_{(2)}$ to its octal equivalent.

Sometimes the binary number will not have even groups of 3bits. For this case, extra 0's can be added to the left of the MSB of the binary number to fill out the last group as shown below:

$11010110_{(2)} = 326_{(8)}$

One added Zero ← 0 11   010   110

3   2   6

Example: convert $1011.01101_{(2)}$ to octal system.

$1011.01101_{(2)} = 13.32_{(8)}$

Two added Zeros ← 0 0 1   011 · 011   01 0 → One added Zero

1   3 · 3   2

Hexadecimal Number System:

The hexadecimal system uses base 16. Thus, it has 16 possible digit symbols. It uses the digits 0 through 9 plus the letters (A,B,C,D,E and F) as the 16 digit symbols. Table (3) shows the relationships among hexadecimal, decimal, and binary digits.

Table (3)

Hexadecimal	Decimal	Binary
0	0	0000
1	1	0001
2	2	0010
3	3	0011
4	4	0100

9

University of Anbar
College of Engineering
Dept. of Electrical Engineering

Subject / Digital Techniques
Second Stage / 1st Semester
(2017 – 2018)

5	5	0101
6	6	0110
7	7	0111
8	8	1000
9	9	1001
A	10	1010
B	11	1011
C	12	1100
D	13	1101
E	14	1110
F	15	1111

Hex-to-Decimal Conversion:

a hex number can be converted to its decimal equivalent by using the fact that each hex digit position has a weight that is a power of 16. the LSD has a weight of $16^0 = 1$, the next higher digit has a weight of $16^1 = 16$, the next higher digit has a weight of $16^2 = 256$, and so on. The conversion is demonstrated in the examples below:

$$356_{(16)} = 3 \times 16^2 + 5 \times 16^1 + 6 \times 16^0$$
$$= 768 + 80 + 6 = 854_{(10)}$$

$$2AF_{(16)} = 2 \times 16^2 + 10 \times 16^1 + 15 \times 16^0$$
$$= 512 + 160 + 15 = 687_{(10)}$$

Decimal-to-Hex Conversion:

Recall that we did decimal-to-binary conversion using repeated division by 2, and decimal-to-octal conversion using repeated division by 8. Likewise, decimal-to-Hex conversion can be done using repeated division by 16.

University of Anbar
College of Engineering
Dept. of Electrical Engineering

Subject / Digital Techniques
Second Stage / 1st Semester
(2017 – 2018)

_____

Example: convert $423_{(10)}$ to hex.

$$\frac{423}{16} = 26 + \text{Remainder } 7$$

$$\frac{26}{16} = 1 + \text{Remainder } 10$$

$$\frac{1}{16} = 0 + \text{Remainder } 1$$

$$423_{(10)} = 1A7_{(16)}$$

Example: convert $214_{(10)}$ to hex.

$$\frac{214}{16} = 13 + \text{Remainder } 6$$

$$\frac{13}{16} = 0 + \text{Remainder } 13$$

$$214_{(10)} = D6_{(16)}$$

Hex-to-Binary Conversion:

Each Hex digit is converted to its 4-bit binary equivalent. This is illustrated below for $9F2_{(16)}$.

$$9F2_{(16)} = 100111110010_{(2)}$$

$$
\begin{array}{ccc}
9 & F & 2 \\
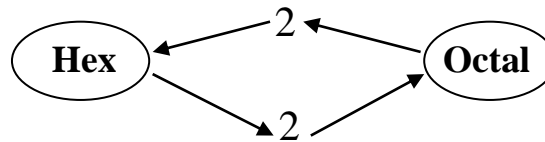\downarrow & \downarrow & \downarrow \\
1001 & 1111 & 0010
\end{array}
$$

Binary-to-Hex Conversion:

This conversion is just the reverse of the process of Hex-to-Decimal conversion. The binary number is grouped into groups of 4bits, and each group is converted to its equivalent hex digit as in the example below:

$$
\begin{array}{ccc}
1011 & 1010 & 0110 \\
\downarrow & \downarrow & \downarrow \\
B & A & 6
\end{array}
$$

11

University of Anbar
College of Engineering
Dept. of Electrical Engineering

Subject / Digital Techniques
Second Stage / 1st Semester
(2017 – 2018)

$101110100110_{(2)} = BA6_{(16)}$

Hex-to-Octal Conversion:

Review Questions:

1. What is the binary equivalent of decimal number 363? convert to octal and then to binary?

2. What is the largest number that can be represented using 8 bits?

3. What is the decimal equivalent of $1101011_{(2)}$?

4. What is the next binary number following $10111_{(2)}$ in the counting sequence?

5. What is the weight of the MSB of a 16-Bit number?

6. Convert $614_{(8)}$ to decimal?

7. Convert $146_{(10)}$ to octal?

8. Convert $24CE_{(16)}$ to decimal?

9. Convert $3117_{(10)}$ to hex, then from hex to binary?

10. Solve for x in the following equation: $1011.11_{(2)} = x_{(10)}$?

11. Solve for x in the following equation: $174.3_{(8)} = x_{(10)}$?

12. Solve for x in the following equation: $10949.8125_{(10)} = x_{(2)}$?

13. Solve for x in the following equation: $2C6B.F2_{(16)} = x_{(2)}$?

University of Anbar
College of Engineering
Dept. of Electrical Engineering

Subject / Digital Techniques
Second Stage / 1st Semester
(2017 – 2018)

Arithmetic Operation

Addition of Binary Numbers:

The addition of two binary numbers is performed in exactly the same manner as the addition of decimal numbers. Only four cases can occur in adding the two binary digits (bits) in any position. They are:

0+0=0
1+0=1
0+1=1
1+1=0   with carry 1
1+1+1=1 with carry 1

Examples:

```
  011   (3)        1001  (9)        11.011   (3.375)      1010 (10)
+ 110   (6)      + 1111  (15)     + 10.110   (2.750)    + 1101 (13)
  1001  (9)       11000 (24)       110.001   (6.125)     10111 (23)
```
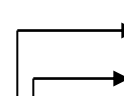
Subtraction of Binary Numbers (Using Direct Method):

The four basic rules for subtracting binary digits are:

0-0=0
1-1=0
1-0=1
0-1=1   with borrow 1

Examples:

when 1 is borrowed, a 0 is left .

when 1 is borrowed, making 10 instead of 0.

```
   11   (3)         11   (3)         101   (5)
 - 01   (1)       - 10   (2)       - 011   (3)
   10   (2)         01   (1)         010   (2)
```

Subtraction of Binary Numbers (Using Complement Method):

The 1's complement and the 2's complement of a number are important because they permit the representation of negative numbers. The method of 2's complement arithmetic is used in computer to handle negative numbers