K.C.E. SOCIETY'S

COLLEGE OF ENGINEERING & MANAGEMENT, JALGAON

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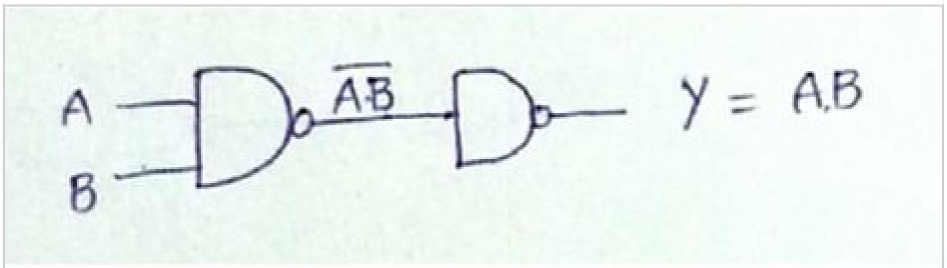
DIGITAL ELECTRONICS AMD MICROPROCESSOR

Question 1: Realize the following gates by only using NAND Gates.

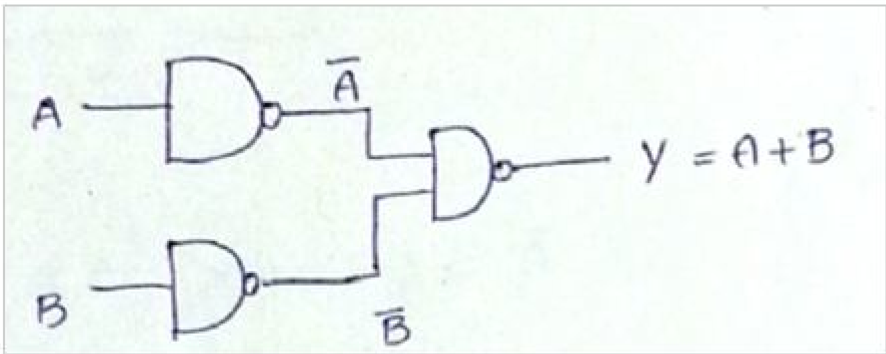
i. AND
ii. OR
iii. NOT
iv. NOR
v. XOR
vi. XNOR

Answer:

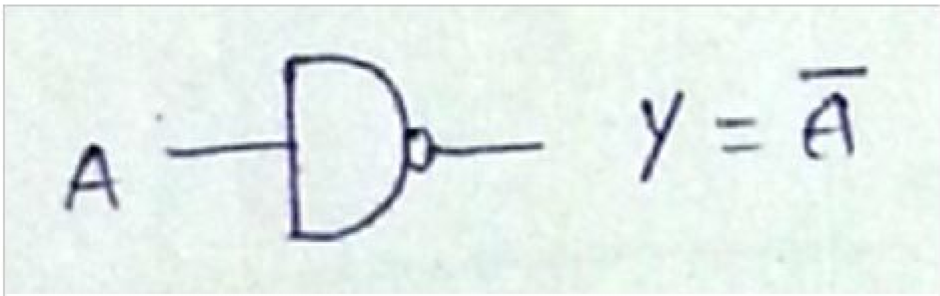
i. AND Gate can be implemented using NAND Gate as:



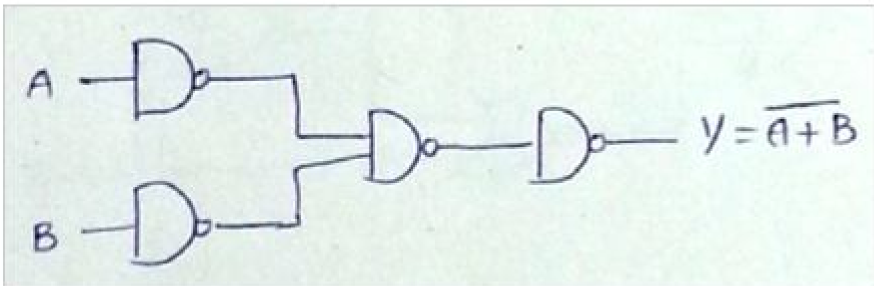
ii. OR Gate can be implemented using NAND Gate as:



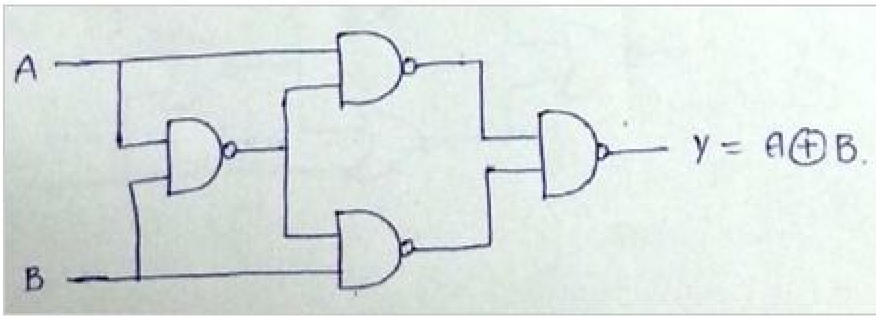
iii. NOT Gate can be implemented using NAND Gate as:



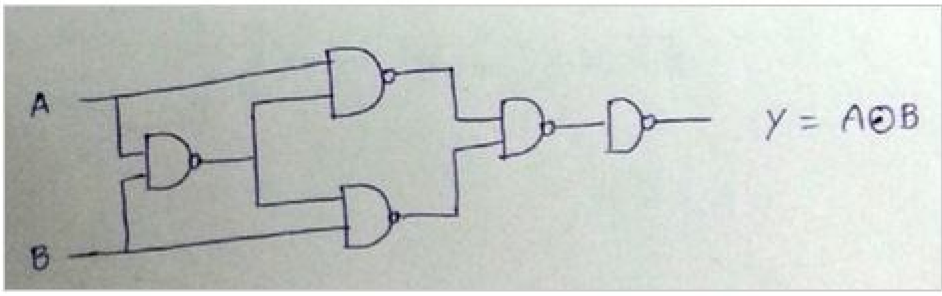
iv. NOR Gate can be implemented using NAND Gate as:



v. XOR Gate can be implemented using NAND Gate as:



vi. XNOR Gate can be implemented using NAND Gate as:



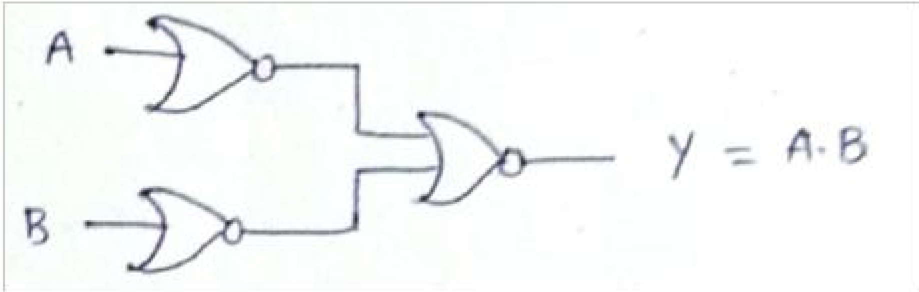
Question 2: Realize the following gates by only using NOR Gates.

i. AND
ii. OR
iii. NOT

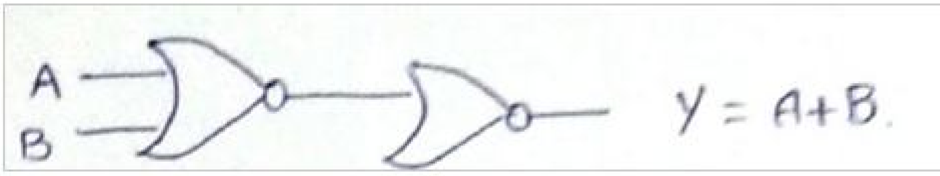
iv. NOR
v. XOR
vi. XNOR

Answer:

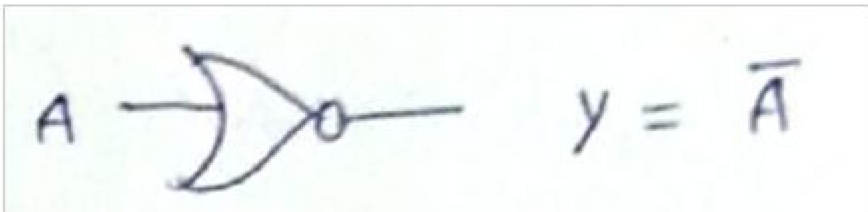
i. AND Gate can be implemented using NOR Gate as:



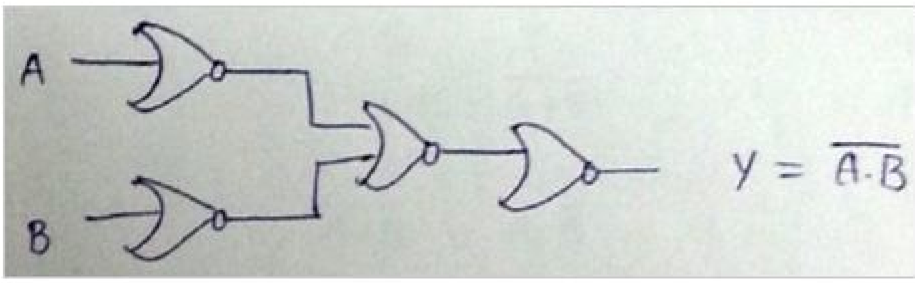
ii. OR Gate can be implemented using NOR Gate as:



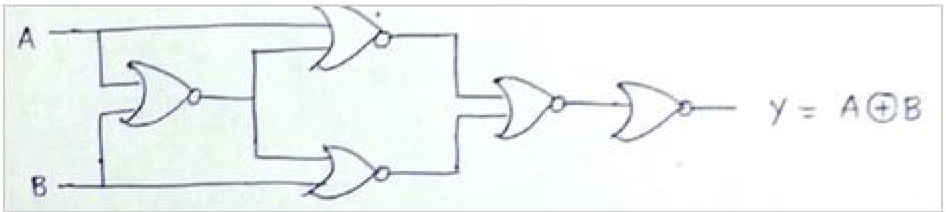
iii. NOT Gate can be implemented using NOR Gate as:



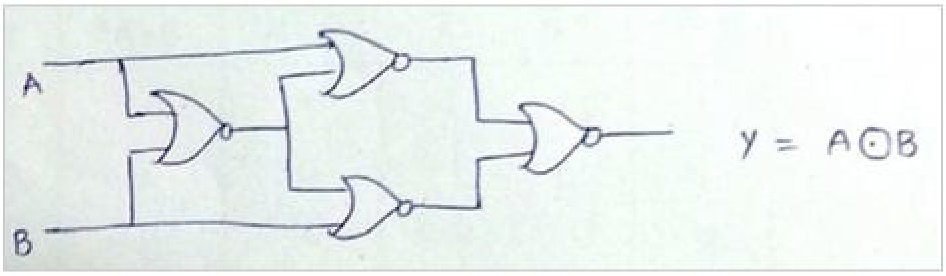
iv. NAND Gate can be implemented using NOR Gate as:



v. XOR Gate can be implemented using NOR Gate as:



vi. XNOR Gate can be implemented using NOR Gate as:



Boolean Algebra

Computer Number Systems and its types

What are the number systems in Computer?

Number systems are the technique to represent numbers in the computer system architecture, every value that you are saving or getting into/from computer memory has a defined number system.

Computer architecture supports following number systems.

- **Binary number system**
- **Octal number system**
- **Decimal number system**
- **Hexadecimal (hex) number system**

1) Binary Number System

A Binary number system has only two digits that are **0 and 1**. Every number (value) represents with 0 and 1 in this number system. The base of binary number system is 2, because it has only two digits.

2) Octal number system

Octal number system has only eight (8) digits from **0 to 7**. Every number (value) represents with 0,1,2,3,4,5,6 and 7 in this number system. The base of octal number system is 8, because it has only 8 digits.

3) Decimal number system

Decimal number system has only ten (10) digits from **0 to 9**. Every number (value) represents with 0,1,2,3,4,5,6, 7,8 and 9 in this number system. The base of decimal number system is 10, because it has only 10 digits.

4) Hexadecimal number system

A Hexadecimal number system has sixteen (16) alphanumeric values from **0 to 9** and **A to F**. Every number (value) represents with 0,1,2,3,4,5,6, 7,8,9,A,B,C,D,E and F in this number system. The base of hexadecimal number system is 16, because it has 16 alphanumeric values. Here **A is 10**, **B is 11**, **C is 12**, **D is 13**, **E is 14** and **F is 15**.

Table of the Numbers Systems with Base, Used Digits, Representation, C language representation:

Number system	Base	Used digits	Example	C Language assignment
Binary	2	0,1	$(11110000)_2$	int val=0b11110000;
Octal	8	0,1,2,3,4,5,6,7	$(360)_8$	int val=0360;
Decimal	10	0,1,2,3,4,5,6,7,8,9	$(240)_{10}$	int val=240;
Hexadecimal	16	0,1,2,3,4,5,6,7,8,9, A,B,C,D,E,F	$(F0)_{16}$	int val=0xF0;

Number System Conversions

There are three types of conversion:

- **Decimal Number System to Other Base**
  [for example: Decimal Number System to Binary Number System]
- **Other Base to Decimal Number System**
  [for example: Binary Number System to Decimal Number System]
- **Other Base to Other Base**
  [for example: Binary Number System to Hexadecimal Number System]

Decimal Number System to Other Base

To convert Number system from **Decimal Number System** to **Any Other Base** is quite easy; you have to follow just two steps:
A) Divide the Number (Decimal Number) by the base of target base system (in which you want to convert the number: Binary (2), octal (8) and Hexadecimal (16)).

B) Write the remainder from step 1 as a Least Signification Bit (LSB) to Step last as a Most Significant Bit (MSB).

Decimal to Binary Conversion

Decimal to Binary Conversion	Result
Decimal Number is : **(12345)$_{10}$**	Binary Number is **(11000000111001)$_2$**

2	12345	1	**LSB**
2	6172	0	↑
2	3086	0	
2	1543	1	
2	771	1	
2	385	1	
2	192	0	
2	96	0	
2	48	0	
2	24	0	
2	12	0	
2	6	0	
2	3	1	
	1	1	**MSB**

Decimal to Octal Conversion	Result
Decimal Number is : **(12345)$_{10}$**	Octal Number is **(30071)$_8$**

8	12345	1	LSB
8	1543	7	
8	192	0	
8	24	0	
	3	3	MSB

Decimal to Hexadecimal Conversion	Result
Example 1 Decimal Number is : **(12345)$_{10}$**	Hexadecimal Number is **(3039)$_{16}$**

16	12345	9	**LSB**
16	771	3	
16	48	0	
8	3	3	**MSB**

Example 2 Decimal Number is : **(725)$_{10}$**	Hexadecimal Number is **(2D5)$_{16}$** **Convert** **10, 11, 12, 13, 14, 15** **to its equivalent...** **A, B, C, D, E, F**

16	725	5	5	**LSB**
16	45	13	D	
	2	2	2	**MSB**

Other Base System to Decimal Number Base

To convert Number System from **Any Other Base System** to **Decimal Number System**, you have to follow just three steps:
A) Determine the base value of source Number System (that you want to convert), and also determine the position of digits from LSB (first digit's position – 0, second digit's position – 1 and so on).
B) Multiply each digit with its corresponding multiplication of position value and Base of Source Number System's Base.
C) Add the resulted value in step-B.

Explanation regarding examples:
Below given exams contains the following rows:
A) Row 1 contains the **DIGITs** of number (that is going to be converted).
B) Row 2 contains the **POSITION** of each digit in the number system.
C) Row 3 contains the multiplication: **DIGIT* BASE^POSITION**.
D) Row 4 contains the calculated result of **step C**.
E) And then add each value of **step D**, resulted value is the Decimal Number.

Binary to Decimal Conversion

Binary Number is : **$(11000000111001)_2$**

1	1	0	0	0	0	0	0	1	1	1	0	0	1
13	12	11	10	9	8	7	6	5	4	3	2	1	0
$1x2^{13}$	$1x2^{12}$	$0x2^{11}$	$0x2^{10}$	$0x2^9$	$0x2^8$	$0x2^7$	$0x2^6$	$1x2^5$	$1x2^4$	$1x2^3$	$0x2^2$	$0x2^1$	$1x2^0$
8192	4096	0	0	0	0	0	0	32	16	8	0	0	1

=8192+4096+32+16+8+1
=12345

Octal to Decimal Conversion

Octal Number is : **$(30071)_8$**

3	0	0	7	1
4	3	2	1	0
$3*8^4$	$0*8^3$	$0*8^2$	$7*8^1$	$1*8^0$
12288	0	0	56	1

Result

=12288+0+0+56+1
=12345
Decimal Number is:
$(12345)_{10}$

Hexadecimal to Decimal Conversion

Hexadecimal Number is : **$(2D5)_{16}$**

2	D (13)	5
2	1	0
$2*16^2$	$13*16^1$	$5*16^0$
512	208	5

Result

=512+208+5
=725
Decimal Number is: **$(725)_{10}$**

Conversion of Decimal Number System into Binary Number System

In this method, the **decimal integer number is converted to a binary integer** by successive division by 2, and the decimal fraction is **converted to a binary fraction** by successive multiplication by 2.

The decimal integer number is successively divided by 2 until the quotient is 0. The last remainder is the MSB. The remainders read starting from the bottom to the top give the equivalent binary integer number.

The decimal fractional number is successively multiplied by 2, till the fractional part of the product is 0. The first integer obtained is the MSB, thus the integers read from top to bottom gives the equivalent binary fraction.

To convert a mixed number to binary, we have to convert the integer and fractional part to binary separately and then combine them.

Example 1:

Convert $(13.25)_{10}$ to $(?)_2$

Solution:

In 13.25, we have 13 as the integral part and 0.25 as the fractional part. To get an equivalent binary number, we have to convert both to binary separately and then combine them.

Integral Part

Divisor	Quotient	Remainder
2	13	
2	6	1 LSB
2	3	0
2	1	1
2	0	1 MSB

All the remainders read from top to bottom, where topmost is the LSB and bottom one is the MSB.

Therefore, $(13)_{10} = (1101)_2$

Fractional Part

```
0.25 * 2 = 0.50   MSB
0.50 * 2 = 1.00   LSB
```

Integer part of the product term read from top to bottom.

Therefore, $(0.25)_{10} = (0.01)_2$

Now, we can combine both the integral part and the fractional part to get the required binary equivalent i.e., **$(13.25)_{10} = (1101.01)_2$**

Example 2:

Convert $(15.6)_{10}$ to $(?)_2$

Solution:

Converting Integral and Fractional part separately.

Integral Part

Divisor	Quotient	Remainder
2	15	
2	7	1 LSB
2	3	1
2	1	1
2	0	1 MSB

All the remainders read from top to bottom, where topmost is the LSB and bottom one is the MSB.

Therefore, $(15)_{10} = (1111)_2$

Fractional Part

```
0.6 * 2 = 1.2             MSB
0.2 * 2 = 0.4
0.4 * 2 = 0.8
0.8 * 2 = 1.6
0.6 * 2 = 1.2
0.2 * 2 = 0.4
0.4 * 2 = 0.8
0.8 * 2 = 1.6             LSB
```

Integer part of all the product terms read from top to bottom.

Therefore, $(0.6)_{10} = (0.\underline{1001})_2$

Now, we can combine both the integral part and the fractional part to get the required binary equivalent i.e., **$(15.6)_{10} = (1111.\underline{1001})_2$**

Note: If the numbers are non-terminating and non-repeating then, in that case, the process of multiplication is to be stopped after 4 or 5 decimal places.

Example 3:

Convert $(18.75)_{10}$ to $(?)_2$

Solution:

In 18.75, 18 is the integral part and 0.75 is the decimal part. To convert 18.75 into binary we first have to convert integral and fractional part individually and then combine them together.

Integral Part

Divisor	**Quotient**	**Remainder**
2	18	
2	9	0 LSB
2	4	1
2	2	0
2	1	0
2	0	1 MSB

All the remainders read from top to bottom, where topmost is the LSB and bottom one is the MSB.

Therefore, $(18)_{10} = (10010)_2$

Fractional Part

```
0.75 * 2 = 1.50    MSB
0.50 * 2 = 1.00    LSB
```

Integer part of all the product terms read from top to bottom.

Therefore, $(0.75)_{10} = (0.11)_2$

Now, we can combine both the integral part and the fractional part to get the required binary equivalent i.e., **$(18.75)_{10} = (10010.11)_2$**

Conversion of Decimal Number System into Octal Number System

Converting a number from Decimal to Octal is almost similar to converting Decimal into Binary, although just one difference is that unlike Binary conversion, here in an integral part, we successively divide the number by 8 until the quotient is 0 (the last remainder becomes the MSB). The remainders read from bottom to top give the equivalent octal integer number. and in the fractional part, we multiply it by 8 till the fractional part of the product is 0. The first integer in the product term gives the MSB, thus the integers read from top to bottom gives the equivalent octal fraction.

Same as in decimal to binary conversion, to **convert a mixed decimal number into octal**, we first separate the integral and the fractional part and then convert them into octal individually, after converting both to octal separately, we combine them back together to get the desired result.

Example 1:

Convert $(73.625)_{10}$ to $(?)_8$

Solution:

Firstly, we will separate the integral part $(73)_8$ and the fractional part $(0.625)_8$. Now, we will convert each of them to octal individually.

Integral Part

Divisor	Quotient	Remainder
8	73	
8	9	1 LSB
8	1	1
8	0	1 MSB

All the remainders read from top to bottom, where topmost is the LSB and bottom one is the MSB.

Therefore, $(73)_{10}$ = $(111)_8$

Fractional Part

```
0.625 * 8 = 5.000
```

The integer part of the product term read from top to bottom forms the equivalent octal number i.e., **$(.625)_{10}$ = $(0.5)_8$**

After converting both integral part and fractional part individually into octal, now we combine both to get our desired result i.e., **$(73.625)_{10}$ = $(111.5)_8$**

Example 2:

Convert $(965.198)_{10}$ to $(?)_8$

Solution:

Integral Part

Divisor	Quotient	Remainder
8	965	
8	120	5 LSB
8	15	0

8	1	7
8	0	1 MSB

The remainders read from bottom to top gives the equivalent octal number i.e., **$(965)_{10}$ = $(1705)_8$**.

Fractional Part

```
0.198 * 8 = 1.584  MSB
0.584 * 8 = 4.672
0.672 * 8 = 5.376
0.376 * 8 = 3.008
0.008 * 8 = 0.064
0.064 * 8 = 0.512  LSB
```

The integer part of the product term read from top to bottom forms the equivalent octal number i.e., **$(0.198)_{10}$ = $(0.145300)_8$**.

After converting both integral part and fractional part individually into octal, now we combine both to get our desired result i.e., **$(965.198)_{10}$ = $(1705.145300)_8$**

Example 3:

Convert $(296.225)_{10}$ to $(?)_8$

Solution:

Integral Part

Divisor	**Quotient**	**Remainder**
8	296	
8	37	0 LSB
8	4	5
8	0	4 MSB

The remainders read from bottom to top gives the equivalent octal number i.e., **$(296)_{10}$ = $(450)_8$**.

Fractional Part

```
0.225 * 8 = 1.80    MSB
0.80  * 8 = 0.64
0.64  * 8 = 5.12
0.12  * 8 = 0.96
0.96  * 8 = 7.68     LSB
```

The integer part of the product term read from top to bottom forms the equivalent octal number i.e., **$(0.198)^{10}$ = $(0.10507)^{8}$**.

After converting both integral part and fractional part individually into octal, now we combine both to get our desired result i.e., **$(296.225)_{10}$ = $(450.10507)_8$**.

Conversion of Decimal Number System into Hexadecimal Number System

Conversion of decimal number system into hexadecimal number system can be done by successively dividing an integral part by 16 till the quotient is 0 and then reading the remainder of all in the bottom to the top manner, where the bottom one is the MSB and the topmost is the LSB. For fractional part, we successively multiply it by 16 till we get 0 in the fractional part of the product term, the integral part of the product term recorded from top to bottom forms the respective hexadecimal number where topmost is the MSB.

To **convert a mixed decimal number into hexadecimal**, we will first convert integral and fractional parts into hexadecimal and then combine them.

The only thing to be kept in mind is the digits in hexadecimal number system are as:

1 , 2, 3, 4, 5, 6, 7, 8, 9, 10 = A, 11 = B, 12 = C, 13 = D, 14 = E, 15 = F

Now let's take examples to understand the **conversion of decimal number to hexadecimal number**.

Example 1:

Convert $(1954.785)_{10}$ to $(?)_{16}$

Solution:

Given decimal number $(1954.785)_{10}$ is of mixed type and contains both integral $(1954)_{10}$ and decimal part $(0.785)_{10}$. To convert the given number into hexadecimal, we have to convert integral and fractional part individually into hexadecimal and then combine them together to get the required result.

Integral Part

Divisor	Quotient	Remainder
16	1954	
16	122	2 LSB
16	7	10 = A
16	0	7 MSB

The remainders read from bottom to top gives the equivalent hexadecimal number i.e., **$(1954)_{10}$ = $(7A2)_{16}$**.

Fractional Part

```
0.785 * 16 = 12.56 = C.56     (MSB)
0.56 * 16 = 8.96
0.96 * 16 = 15.36 = F.36
0.36 * 16 = 5.76
0.76 * 16 = 12.16 = C.16    (LSB)
```

The integer part of the product term read from top to bottom forms the equivalent hexadecimal number i.e., **$(0.785)_{10}$ = $(0.C8F5C)_{16}$**.

After converting both integral part and fractional part individually into hexadecimal, now we combine both to get our desired result i.e., **$(1954.785)_{10}$ = $(7A2.C8F5C)_{16}$**.

Example 2:

Convert $(3283.715)_{10}$ to $(?)_{16}$

Solution:

Integral Part

Divisor	Quotient	Remainder
16	3283	
16	205	3 LSB
16	12	13=D
16	0	12=C MSB

The remainders read from bottom to top gives the equivalent hexadecimal number i.e., **$(3283)_{10}$ = $(CD3)_{16}$**.

Fractional Part

```
0.715 * 16 = 11.44 = B.44   (MSB)
0.44 * 16 = 7.04
0.04 * 16 = 0.64
0.64 * 16 = 10.24 = A.24    (LSB)
```

The integer part of the product term read from top to bottom forms the equivalent hexadecimal number i.e., **$(0.715)_{10}$ = (0. B70A)$_{16}$**.

After converting both integral part and fractional part individually into hexadecimal, now we combine both to get our desired result i.e., **$(3283.715)_{10}$ = (CD3. B70A)$_{16}$**.

Example 3:

Convert $(356.225)_{10}$ to $(?)_{16}$

Solution:

Integral Part

Divisor	Quotient	Remainder
16	356	
16	22	4 LSB
16	1	6
16	0	1 MSB

The remainders read from bottom to top gives the equivalent hexadecimal number i.e., **$(356)_{10}$ = $(164)_{16}$**.

Fractional Part

```
0.225 * 16 = 3.600        (MSB)
0.600 * 16 = 9.600
0.600 * 16 = 9.600
0.600 * 16 = 9.600        (LSB)
```

The integer part of the product term read from top to bottom forms the equivalent hexadecimal number i.e., **$(0.225)_{10}$ = $(0.3\underline{9})_{16}$**.

After converting both integral part and fractional part individually into hexadecimal, now we combine both to get our desired result i.e., **$(356.225)_{10}$ = $(164.3\underline{9})_{16}$**.

Conversion of Binary Number System to Decimal Number System

To **convert binary number to its respective decimal number** we use the place values or what we call the positional weights and multiply it with the corresponding bit and add them all together to obtain the decimal number.

- In an **integral part of the binary number**, the weights follow the pattern as 2^0, 2^1, 2^2, 2^3, 2^4, 2^5 and so on from right to left.
- In the **fractional part of the binary number**, the weights follow the pattern as 2^{-1}, 2^{-2}, 2^{-3}, 2^{-4}, 2^{-5} and so on from left to right.

To **convert a mixed binary number**, we convert its integral and fractional part individually and then combine them to get the desired decimal number.

Let's take a few examples to understand the concept better.

Example 1: Convert $(101.11)_{10}$

Solution:

Now, after converting both integral part and fractional part separately, we combine them and get the desired decimal number for the binary number i.e., **(101.11)2 = (5.75)10**

Example 2: Convert (11011.101)10

Solution:

Now, after converting both integral part and fractional part separately, we combine them and get the desired decimal number for the binary number i.e., **(11011.101)2 = (27.625)10**

Conversion of Binary Number System into Octal Number System

To **convert binary numbers into octal numbers**, we first have to understand the relationship between binary and octal numbers.

Octal Number	Binary Number
0	000
1	001
2	010
3	011
4	100
5	101
6	110
7	111

In octal number system, we have eight digits ranging from **0 to 7** which can be represented using **three-bit binary numbers** in $\mathbf{2^3 = 8}$ ways, so starting from the least significant bit of the binary number, we group three successive bits of the binary number to get its equivalent octal number as seen from the table above.

In an **integral part**, the grouping of three bits is done from the right side to the left side whereas in the **fractional part** the grouping of three bits is done from left to right and then convert it to its equivalent octal symbol.

In the process of grouping three bits, one or two bits can be added to the left of the MSB in an integral part and/or to the right of the LSB bit of the fractional part of the binary number.

Example 1: Convert $(110011.011)_2$ to $(?)_8$

Therefore, $\mathbf{(110011.011)_2 = (63.3)_8}$

Example 2: Convert $(110011011110.1011)_2$ to $(?)_8$

Therefore, **$(110011011110.1011)_2 = (14676.54)_8$**

Note: In the Example 2, to make a group of three bits, we have added two additional bits to the left of MSB in an integral part and two additional bits to the right of LSB in the fractional part.

Conversion of Binary Number System into Hexadecimal Number System

Converting binary numbers into hexadecimal numbers is similar to the conversion of binary into octal, it just requires some modifications. The relationship between binary numbers and hexadecimal numbers is given as:

Decimal	Hexadecimal	Binary
0	0	0000
1	1	0001
2	2	0010
3	3	0011
4	4	0100
5	5	0101
6	6	0110
7	7	0111
8	8	1000
9	9	1001
10	A	1010
11	B	1011
12	C	1100
13	D	1101
14	E	1110
15	F	1111

In hexadecimal number system, we have sixteen digits ranging from **0 to 15** which can be represented using **four-bit binary numbers** in **$2^4 = 16$** ways, so starting from the least significant bit of the binary number, we group four successive bits of the binary number to get its equivalent hexadecimal number as seen from the table above.

In an integral part, the grouping of four bits is done from the right side to the left side whereas in the fractional part the grouping of four bits is done from left to right and then convert it to its equivalent hexadecimal symbol.

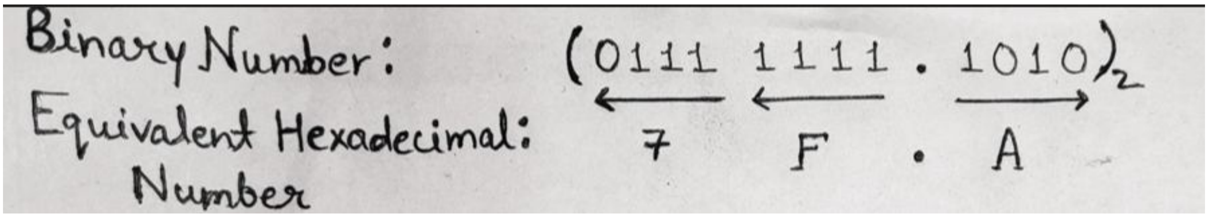
In the process of grouping four bits, one/two/three bits can be added to the left of the MSB in an integral part and/or to the right of the LSB bit of the fractional part of the binary number.

Note: Whenever we need any additional bits, we only add '0' as the additional bit.

Example 1: Convert $(01111111.1010)_2$ to $(?)_{16}$

Solution:

We will make a grouping of 4 bits from right to left direction in an integral part and from left to right direction in the fractional part and then replace it with the corresponding symbol with the help of the table provided above.



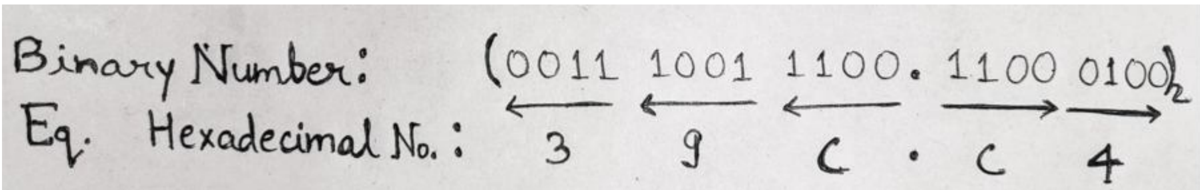
Therefore, **$(01111111.1010)_2 = (7F. A)_{16}$**

Example 2: Convert $(1110011100.110001)_2$ to $(?)_{16}$

Solution:

The given binary number consists of only 10 bits in an integral part and only 6 bits in the fractional part. So, making a group of 4 bits is not possible. In this case, we have to add bits from our side so that we can make a grouping of 4 bits. Thus, we add two zero bits at the LHS of the MSB in the integral part which will make 12 bits in an integral part, without disturbing its original value. Similarly, two zero bits are added to the RHS of the LSB in the fractional part, which will result in 8 bits in the fractional part and can be grouped in a group of 4 bits.

Thus, above given binary number can now be written as: **$(001110011100.11000100)_2$**

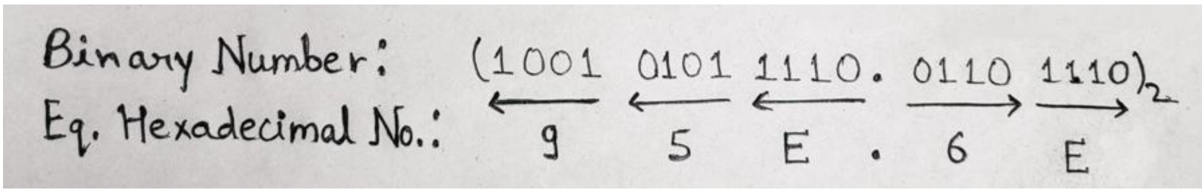


Therefore, **$(001110011100.11000100)_2 = (39C.C4)_{16}$**

Example 3: Convert $(100101011110.0110111)_2$ to $(?)_{16}$

Solution:

Given binary number has 12 bits in an integral part, so it can be easily grouped in a group of 4 bits but there are only 7 bits in the fractional part so we need to add one more additional zero bit to the RHS of LSB in the fractional part. Thus, the above binary number can now be written as: **(1**



00101011110.01101110)$_2$

Therefore, **(100101011110.01101110)$_2$ = (95E.6E)$_{16}$**

Conversion of Octal Number System to Binary, Decimal and Hexadecimal Number Systems

1) Conversion of Octal Number System to Binary Number System

To convert octal numbers into binary numbers, we can use the relationship between octal and binary numbers.

Octal Number	Binary Number
0	000
1	001
2	010
3	011
4	100
5	101
6	110
7	111

Example 1: Convert (73.2)$_8$ into (?)$_2$

Solution:

Using the table provided above, we can replace octal numbers with their equivalent binary digits.

```
7 = 111
3 = 011
```

```
2 = 010
```

Therefore, **$(73.2)_8$ = $(111\ 011.010)_2$**

Example 2: Convert $(475.62)_8$ into $(?)_2$

Solution:

Using the table provided above, we can replace octal numbers with their equivalent binary digits.

```
4 = 100
7 = 111
5 = 101
6 = 110
2 = 010
```

Therefore, **$(475.62)_8$ = $(100\ 111\ 101.110\ 010)_2$**

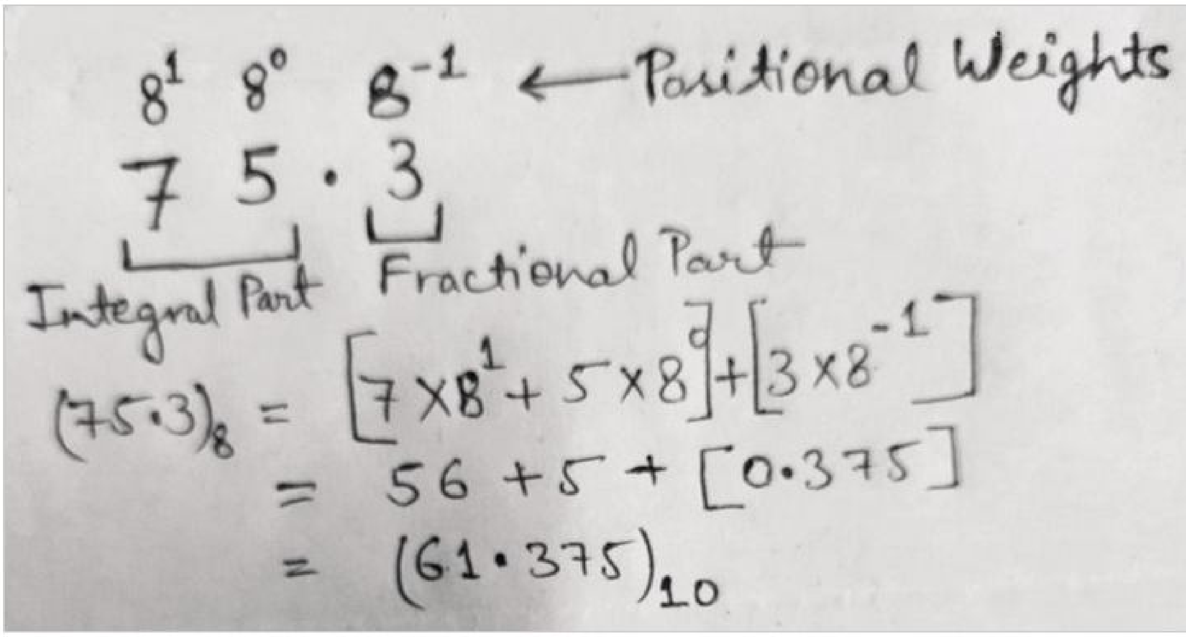
2) Conversion of Octal Number System to Decimal Number System

Conversion of octal number into a decimal number can be done using the positional weights by multiplying the positional weights with the corresponding bit and add them all together to obtain the decimal number.

- In an integral part of the octal number, the weights follow the pattern as $\mathbf{8^0}$, $\mathbf{8^1}$, $\mathbf{8^2}$, $\mathbf{8^3}$, $\mathbf{8^4}$, $\mathbf{8^5}$ and so on from right to left.
- In the fractional part of the octal number, the weights follow the pattern as $\mathbf{8^{-1}}$, $\mathbf{8^{-2}}$, $\mathbf{8^{-3}}$, $\mathbf{8^{-4}}$, $\mathbf{8^{-5}}$ and so on from left to right.

Example 1: Convert $(75.3)_8$ = $(?)_{10}$

Solution:



We multiply each bit with the corresponding positional weight and then add them together to get the result.

Therefore, **$(75.3)_8$ = $(61.375)_{10}$**

Example 2: Convert $(624.712)_8$ = $(\ ? \ )_{10}$

Solution:

$$\begin{array}{ccccccc} 8^2 & 8^1 & 8^0 & & 8^{-1} & 8^{-2} & 8^{-3} \\ 6 & 2 & 4 & \cdot & 7 & 1 & 2 \end{array}$$

$$(624.712)_8 = [6\times8^2+2\times8^1+4\times8^0] + [7\times8^{-1}+1\times8^{-2}+2\times8^{-3}]$$

$$= 384+16+4+0.875+0.015625 + 0.00390625$$

$$= (404.894)_{10}$$

We multiply each bit with the corresponding positional weight and then add them together to get the result.

Therefore, **$(624.712)_8$ = $(404.894)_{10}$**

Example 3: Convert $(482.31)_8$ = $(\ ? \ )_{10}$

Solution:

Given number **$(482.31)_8$ is not an octal number as a range of octal number is from 0 to 7 and the given number includes 8. So, it cannot be converted to a decimal number**.

3) Conversion of Octal Number System into Hexadecimal Number System

Conversion of the octal number to hexadecimal can only be done using a certain definite path. We first have to convert octal number to binary number and then convert the binary number into hexadecimal number i.e., **Octal Number → Binary Number → Hexadecimal Number**

Example 1: Convert $(35.7)_8$ into $(?)_{16}$

Solution:

Step 1: Convert octal number to binary number.
Therefore, **$(35.7)_8 = (011101.111)_2$**

Step 2: Convert binary number to a hexadecimal number.
Therefore, **$(011101.111)_2 = (1D.E)_{16}$**

Therefore, **$(35.7)_8 = (1D.E)_{16}$**

Note: To know how to convert the binary number into a hexadecimal number?, Read: Conversion of binary number into a hexadecimal number.

Example 2: Convert $(73.2)_8$ into $(?)_{16}$

Solution:

Step 1: Convert octal number to binary number.
Therefore, **$(73.2)_8 = (111011.010)_2$**

Step 2: Convert binary number to a hexadecimal number.
Therefore, **$(111011.010)_2 = (3B.4)_{16}$**

Therefore, **$(73.2)_8 = (3B.4)_{16}$**

Conversion of Hexadecimal Number System to Binary, Octal and Decimal Number Systems

1) Conversion of Hexadecimal Number System to Binary Number System

To convert hexadecimal numbers into binary numbers, we can use the relationship between hexadecimal and binary numbers.

Decimal	Hexadecimal	Binary
0	0	0000
1	1	0001
2	2	0010

3	3	0011
4	4	0100
5	5	0101
6	6	0110
7	7	0111
8	8	1000
9	9	1001
10	A	1010
11	B	1011
12	C	1100
13	D	1101
14	E	1110
15	F	1111

Example 1: Convert $(7A.2C)_{16}$ into $(?)_2$

Solution:

Using the table provided above, we can replace hexadecimal numbers with their equivalent binary digits.

Therefore, **$(7A.2C)_{16} = (0111\ 1010.0010\ 1100)_2$**

Example 2: Convert $(D2A.2B7)_{16}$ into $(?)_2$

Solution:

Using the table provided above, we can replace hexadecimal numbers with their equivalent binary digits.

Therefore, **$(D2A.2B7)_{16} = (1101\ 0010\ 1010.0010\ 1011\ 0111)_2$**

Example 3: Convert $(FF18.5E5)_{16}$ into $(?)_2$

Solution:

Using the table provided above, we can replace hexadecimal numbers with their equivalent binary digits.

Therefore, $\mathbf{(FF18.5E5)_{16} = (1111\ 1111\ 0001\ 1000.\ 0101\ 1110\ 0101)_{2}}$

2) Conversion of Hexadecimal Number System into Octal Number System

Conversion of the hexadecimal number to octal number can be done using a certain definite path. We first have to convert hexadecimal numbers to a binary number and then convert a binary number into octal number i.e., **Hexadecimal Number → Binary Number → Octal Number**

Example 1: Convert $(1D.E)_{16}$ into $(\ ?\ )_{8}$

Solution:

Step 1: Converting the first hexadecimal number into a binary number. Thus, $\mathbf{(1D.E)_{16} = (0001\ 1101.1110)_{2}}$

Step 2: Now, converting the binary number into an octal number which gives $\mathbf{(00011101.1110)_{2} = (35.7)_{8}}$

Therefore, $\mathbf{(1D.\ E)_{16} = (35.7)_{8}}$

Note: To know how to convert binary number into octal number? Read: [conversion of Binary number system to octal number system].

Example 2: Convert $(3B.4)_{16}$ into $(\ ?\ )_{8}$

Solution:

Step 1: Converting the first hexadecimal number into a binary number. Thus, $\mathbf{(3B.4)_{16} = (0011\ 1011.0100)_{2}}$

Step 2: Now, converting the binary number into an octal number which gives $\mathbf{(0011\ 1011.0100)_{2} = (73.20)_{8}}$

Therefore, $\mathbf{(3B.4)_{16} = (73.20)_{8}}$

3) Conversion of Hexadecimal Number System to Decimal Number System

Conversion of hexadecimal number into a decimal number can be done using the positional weights by multiplying the positional weights with the corresponding bit and add them all together to obtain the decimal number.

> In an integral part of the hexadecimal number, the weights follow the pattern as $\mathbf{16^0}$, $\mathbf{16^1}$, $\mathbf{16^2}$, $\mathbf{16^3}$, $\mathbf{16^4}$, $\mathbf{16^5}$ and so on from right to left.
>
> In the fractional part of the hexadecimal number, the weights follow the pattern as $\mathbf{16^{-1}}$, $\mathbf{16^{-2}}$, $\mathbf{16^{-3}}$, $\mathbf{16^{-4}}$, $\mathbf{16^{-5}}$ and so on from left to right.

Only thing to be kept in mind is **A = 10**, **B = 11**, **C = 12**, **D = 13**, **E = 14**, **F = 15**.

Example 1: Convert $(75.3)_{16}$ into $(?)_{10}$

Solution:

$$(75.3)_{16} = 7 * 16^1 + 5 * 16^0 + 3 * 16^{-1}$$
$$= 112 + 5 + 0.1875 = (117.1875)_{10}$$

We multiply each bit with the corresponding positional weight and then add them together to get the result.

Therefore, **$(75.3)_{16} = (117.1875)_{10}$**

Example 2: Convert $(CD3.B70A)_{16}$ into $(?)_{10}$

Solution:

$$(CD3.B70A)_{16} = C*16^2 + D*16^1 + 3*16^0 + B*16^{-1} + 7*16^{-2} + 0*16^{-3} + A*16^{-4}$$
$$= 12*256 + 13*16 + 3*1 + 11/16 + 7/256 + 0 + 10/65536$$
$$= 3072+ 208 + 3 + 0.6875 + 0.0273 + 0.0001$$
$$= (3283.7149)_{10}$$

We multiply each bit with the corresponding positional weight and then add them together to get the result.

Therefore, **$(CD3.B70A)_{16} = (3283.7149)_{10}$**