

# SAMPLE STUDY MATERIAL

## Electronics Engineering ECE / E & T



**Postal Correspondence Course**

**GATE, IES & PSUs**

**Digital Electronics**

**Eii ENGINEERS**  
INSTITUTE OF INDIA

India's Best Institute for IES, GATE & PSUs

**A Team of IES & GATE Toppers**

# CONTENT

1. BINARY SYSTEM .....	3-18
2. BOOLEAN ALGEBRA & LOGIC GATES .....	19-40
3. GATE LEVEL MINIMIZATION .....	41-49
4. DIGITAL LOGIC FAMILIES .....	50-79
5. COMBINATIONAL CIRCUITS .....	80-109
6. SEQUENTIAL DIGITAL CIRCUITS .....	110-132
7. SEMICONDUCTOR MEMORIES .....	133-139
8. A/D AND D/A CONVERTERS .....	140-147
9. PRVIOUS YEAR IES QUESTIONS (ELECTRONICS) .....	148-161
10. PRVIOUS YEAR IES QUESTIONS (ELECTRICAL) .....	162-178
11. PRVIOUS YEAR GATE QUESTIONS (ELECTRONICS) .....	179-192
12. PRVIOUS YEAR GATE QUESTIONS (ELECTRICAL) .....	193-204
13. PRACTICE SET-I (DIGITAL ELECTRONICS) PSU's .....	205-224
14. PRACTICE SET-II (DIGITAL ELECTRONICS) PSU's .....	225-233

www.engineersinstitute.com

India's Best Institute for IES, GATE & PSU's

# CHAPTER-1

## BINARY SYSTEM

**Base Conversion:** A number  $a_n, a_{n-1} \dots a_2, a_1 a_0 \cdot a_{-1} a_{-2} a_{-3} \dots$  expressed in a base  $r$  system has coefficient multiplied by powers of  $r$ .

$$a_n r^n + a_{n-1} r^{n-1} + a_{n-2} r^{n-2} + \dots + a_1 r + a_0 + a_{-1} r^{-1} + a_{-2} r^{-2} + a_{-3} r^{-3} + \dots \quad \dots(A)$$

Coefficients  $a_j$ ; range from 0 to  $r - 1$

### Key Points:

To convert a number of base  $r$  to decimal is done by expanding the number in a power series as in (A)

Then add all the terms.

**Example 1:** Convert following Binary number  $(11010.11)_2$  in to decimal number.

**Solution:**

Base  $r = 2$

$$1 \times 2^4 + 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 0 \times 2^0 + 1 \times 2^{-1} + 1 \times 2^{-2}$$

$$(11010.11)_2 = (26.75)_{10}$$

**Example 2:** Convert  $(4021.2)_5$  in to decimal equivalent

$$\text{Solution: } 4 \times 5^3 + 0 \times 5^2 + 2 \times 5^1 + 1 \times 5^0 + 2 \times 5^{-1}$$

$$= (511.4)_{10}$$

**Example 3:** Convert  $(127.4)_8$  in to decimal equivalent.

$$\text{Solution: } 1 \times 8^2 + 2 \times 8^1 + 7 \times 8^0 + 4 \times 8^{-1} = (87.5)_{10}$$

### Numbers with Different bases:

Decimal (r = 10)	Binary (r = 2)	Octal (r = 8)	Hexadecimal (r = 16)
00	0000	00	0
01	0001	01	1
02	0010	02	2
03	0011	03	3
04	0100	04	4
05	0101	05	5

06	0110	06	6
07	0111	07	7
08	1000	10	8
09	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F

**Example 4:** Convert following hexadecimal number into decimal number:  $(B65F)_{16}$

**Solution:**

$$11 \times 16^3 + 6 \times 16^2 + 5 \times 16^1 + 15 \times 16^0 = (46.687)_{10}$$

**Conversion of decimal number to a number in base r:**

- Separate the number into an integer part and fraction part.
- Divide the number and all successive quotients by r and accumulating the remainders.
- Conversion of decimal fraction is done by multiplying the fraction and all successive fraction and integers are accumulated.

**Example 1:** Convert decimal number 41 to binary.

**Solution:**

	Integer quotient	Remainder	Coefficient	
41/2 =	20	+	1	$a_0 = 1$
20/2 =	10	+	0	$a_1 = 0$
10/2 =	5	+	0	$a_2 = 0$
5/2 =	2	+	1	$a_3 = 1$
2/2 =	1	+	0	$a_4 = 0$
1/2 =	0	+	1	$a_5 = 1$
				$(101001)_2$

$$(41)_{10} \rightarrow (101001)_2$$

**Example 2:** Convert  $(153)_{10}$  to octal.

**Solution:**

Required base  $r$  is 8.

153 are divided by 8 to give integer quotient of 19 and remainder 1. Then 19 are divided by 8 to give integer quotient of 2 and remainder 3. Finally 2 are divided by 8 to give quotient of 0 and remainder of 2.

$$\begin{array}{r|l} 153 & \\ 19 & 1 \\ 2 & 3 \\ 0 & 2 \end{array} \quad \begin{array}{l} \uparrow \\ \leftarrow \\ \leftarrow \end{array} \quad (231)_8$$

Thus  $(153)_{10} \rightarrow (231)_8$

**Example 3:** Convert  $(0.6875)_{10}$  to Binary.

**Solution:** 0.6875 is multiplied by 2 to give an integer and a fraction. The new fraction is multiplied by 2 to give a new integer and new fraction.

This process is continuing until the fraction becomes zero or until the numbers of digits have sufficient accuracy.

	Integer		Fraction		Coefficient
$0.6875 \times 2$	1	+	0.3750		$a_1 = 1$
$0.3750 \times 2$	0	+	0.7500		$a_2 = 0$
$0.7500 \times 2$	1	+	0.5000		$a_3 = 1$
$0.500 \times 2$	1	+	0.0000		$a_4 = 1$

$(0.6875)_2 \rightarrow (0.1011)_2$

**Example 4:** Convert  $(0.513)_{10}$  to octal.

**Solution:**

$0.513 \times 8$	=	4	+	0.104	$a_1 = 4$
$0.104 \times 8$	=	0	+	0.832	$a_2 = 0$
$0.832 \times 8$	=	6	+	0.656	$a_3 = 6$
$0.656 \times 8$	=	5	+	0.248	$a_4 = 5$
$0.248 \times 8$	=	1	+	0.984	$a_5 = 1$
$0.984 \times 8$	=	7	+	0.872	

Answer to seven significant figures is:

$(0.406517\dots)_8$

Thus  $(0.513)_{10} \rightarrow (0.406517)_8$

$$(41.6875)_{10} \rightarrow (101001.1011)_2$$

$$(153.513)_{10} \rightarrow (231.406517)_8$$

**Octal and hexadecimal numbers:**

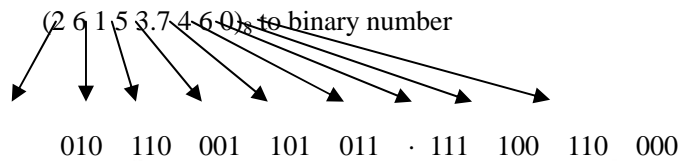
Conversion from binary to octal is easily done by partitioning the binary number into groups of 3 digits each starting from binary point & proceeding to left and to the right.

The corresponding octal digit is then assigned to each group.

For conversion into hexadecimal, binary number is divided into group of 4 digits.

**Example:**  $(26153.7460)_8$  to binary number

Solution:



Thus binary number is

$$(010\ 110\ 001\ 101\ 011.11110011000)_2$$

**Example 5:** Convert binary to hexadecimal number:

$$(10\ 1100\ 0110\ 1011.1111\ 0010)_2$$

$$0010\ 1100\ 0110\ 1011.1111\ 0010$$

$$2\ \ C\ \ 6\ \ B\ \ F\ \ 2 = (2C6B.F2)_{16}$$

**Example 6:**  $(673.124)_8$  to binary number:

$$(673.124)_8 \equiv (110\ 111\ 011.001\ 010\ 100)_2$$

$$6\ \ 7\ \ 3\ \ 1\ \ 2\ \ 4$$

$(306.D)_{16}$  to binary number:

$$(306.D)_{16} \equiv (0011\ 0000\ 0110.1101)_2$$

$$3\ \ 0\ \ 6\ \ D$$

**Note:** In communication, octal or hexadecimal represented is more desirable because it can be expressed more compactly with a third or a quarter of the number of digits required for the equivalent binary number.

**Complements:** Complements are used in digital computer for simplifying the subtraction operations and for logic manipulation.

*There are 2 types of complements for each base r*

*system*

1. Radix complements (r's complement)

2. Diminished radix complement  $((r - 1)$ 's complement

1. Diminished radix complement:

- Given a number  $N$  in base  $r$  having  $n$  digits, the  $(r - 1)$ 's complement of  $N$  is defined as  $(r^n - 1) - N$ .
- For decimal number  $r = 10$ ,  $(r - 1)$ 's complement or 9's complement of  $N$  is  $(10^n - 1) - N$ .

**9's complement:  $(10^n - 1) - N$**

- $10^n$  can be represented as single 1 followed by  $n$  0's
- $10^n - 1$  is number represented by  $n$  9's.
- Thus 9's complement can be obtained by subtracting each digit of number  $N$  by 9's.

**Example 7:** Find 9's complement of 546700

**Solution:**

$$999999 - 546700 = 453299$$

9's complement of 546700 is 453299

**1's Complement for binary number**

- It is given as  $(2^n - 1) - N$
- $2^n$  can be representing as binary number consist of single 1 followed by  $n$  0's.
- $2^n - 1$  can be represented as  $n$  1's.

**Example 8:**  $2_4 \rightarrow 10000$

$$24 - 1 \rightarrow (1111)_2$$

- Thus 1's complement can be obtained as  $(2^n - 1) - N$  or subtracting each digit of number from 1.

**Example 9:** 1's complement of 1011000.

**Solution:**  $1111111 - 1011000 = 0100111$

**Note:** It is similar to changing 1's to 0's and 0's to 1 or complement each digit of number is similar to taking 1's complement of the number.

**Note:**  $(r - 1)$ 's complement of octal or hexadecimal number is obtained by subtracting each digit from 7 and F respectively.

**Example 10:** Obtain 15's complement of number  $(3241)_{16}$

**Solution:** Subtracting each digit of number from FFFF:

F F F F

- 3 2 4 1

C DBE

15's complement is (CDBE)<sub>16</sub>.

**(ii) Radix Complement:**

r's complement of n digit number N in base r is defined as  $r^n - N$  for  $N \neq 0$  & 0 for  $N = 0$

It is equivalent to adding 1 to (r - 1)'s complement.

If (r - 1)'s complement is given, r's complement can be obtained.

**Example:** Find r's complement of 546700 if its 9's complement is 453299.

**Solution:** r's complement is  $453299 + 1$

r's complement = 453300

**Example 11:** 2's complement of 1010110 is.

**Solution:** 1's complement: complement each digit of number (1010110) → (0101001)<sub>2</sub>

Thus 2's complement is  $0101001 + 1$

2's complement = (0101010)<sub>2</sub>

**Another Method to Obtain 10, 2's Complement:**

Leaving all least significant 0's unchanged, subtracting the first non-zero least significant digit from 10 and subtracting all higher significant digits from 9.

**Example 12:** Find 10's complement of 012398.

**Solution:**

1. Subtract 8 from 10 in the least significant position

2. Subtracting all other digits from 9.

9999910

- 01239 8

98760 2

Thus 10's complement of 012398 is 987602.

**Example: 13** 10's complement of 246700.

**Solution:** Leaving 2 least significant 0's unchanged, subtracting 7 from 10 and other 3 digits from 9.

999 10 00



$$\begin{array}{r} - 246\ 700 \\ \hline \end{array}$$

$$753\ 300$$

Thus 10's complement of 246700 is 753300

Similarly 2's complement can be formed by leaving all least significant 0's and first 1 unchanged and replacing 1's with 0's and 0's with 1's in all other higher significant digits.

**Example 14:** 2's complement of  $(1101100)_2$ :

**Solution:**  $1101100$

$\swarrow$        $\searrow$   
 Remain unchanged  
 Remain unchanged  
 Reverse all digits  
 $0010100$

Thus 2's complement of 1101100 is  $(0010100)_2$

**Subtraction with complement:**

1. Convert subtrahend  $N$  to  $r$ 's complement.
2. Then add to the minuend  $M$ .
3. If  $M \geq N$ , sum will produce end carry, which can be discarded, what is left is the result,  $M - N$ .
4. If  $M < N$ , sum does not produce carry and is equal to  $r^n - (N - M)$ , which is same as  $r$ 's complement of  $(N - M)$ .
5. To take the answer in familiar form, take the  $r$ 's complement of the sum and place a negative sign in front.

**Example 15:** Using 10's complement, subtract  $72532 - 3250$

**Solution:**  $M = 72532$

$$N = 03250$$

10's complement of  $N = 96750$

$$\text{Sum: } \begin{array}{r} 72532 \\ \hline \end{array}$$

$$+ 96750$$

$$169282$$

Discard end carry as  $M > N$  so result: 69282

**Example 16:** Using 10's complement, subtract  $3250 - 72532$

**Solution:**  $M = 3250$

$$N = 72532$$

10's complement of 72532 is

$$\begin{array}{r} 9999 \ 10 \\ - 7253 \ 2 \\ \hline \end{array}$$

10's complement 27468

$$\text{Sum: } \quad 3250$$

$$\quad \underline{27468}$$

Sum 30718

Since  $N > M$  so no end carry.

Therefore answer is  $-(10\text{'s complement of } 30718) = -69282$

**Example 16:** Subtract  $1010100 - 1000011$

**Solution:** 2's complement of N ( $1000011$ ) =  $0111101$

$$\text{Sum: } \quad 1010100$$

$$\quad + \underline{0111101}$$

$$\quad 10010001$$

So result is  $0010001$



**Example 17:** Subtract:  $1000011 - 1010100$

**Solution:** 2's complement of  $1010100 \rightarrow 0101100$

$$\text{Sum: } \quad 1000011$$

$$\quad + \underline{0101100}$$

$$\quad 1110111$$

There is no end carry. Therefore, answer is  $-(2\text{'s complement of } 1110111)$

$$= -0010001$$

Note: Subtraction can also be done using  $(r - 1)$ 's complement.

Signed Binary numbers: When binary number is signed, left most bit represents the sign and rest of bits represent the number.

- If binary number is unsigned, then left most bits is the most significant bit of the number.
- Positive or Negative can be represented by (0 or 1) bit which indicate the sign.

**Example 19:** String of bits 01001 can be considered as 9 (unsigned binary) or +9 (signed binary) because left most bits are 0.

**Example 20:** String of bits 11001 represent 25 when considered as unsigned number or – 9 when considered as signed number.

**Negative number representation:**

(i) Signed magnitude representation: In this representation number consist of a magnitude and a symbol (+ or -) or bit (0 or 1) indicating the sign. left most bit represents sign of a number.

Eğ. : 11001 → - 9

01001 → +9

(ii) Signed complement system:

- In this system, negative number is indicated by its complement.
- It can use either 1's or 2's complement, but 2's complement is most common.

**Note:**

1. 2's complement of positive number remain number itself.
2. In both signed magnitude & signed complement representation, the left most significant bit of negative numbers is always 1.

**Example:** +9 @ 00001001

- 9 @ 11110111 (2's complement of +9)

**Note:** Signed complement of number can be obtained by taking 2's complement of positive number including the sign bit.

- Signed magnitude system is used in ordinary arithmetic, can not employed in computer arithmetic because of separate handling of the sign and the magnitude.
- In computer arithmetic signed complement system is used to represent negative numbers.

Decimal	Signed 2'Complement	Signed 1's complement	Signed magnitude
<b>+4</b>	0100	0100	<b>0100</b>
<b>+3</b>	0011	0011	<b>0011</b>
<b>+2</b>	0010	0010	<b>0010</b>
<b>+1</b>	0001	0001	<b>0001</b>
<b>+0</b>	0000	0000	<b>0000</b>
<b>-0</b>	-	1111	<b>1000</b>
<b>-1</b>	1111	1110	<b>1001</b>

-2	1110	1101	<b>1010</b>
-3	1101	1100	<b>1011</b>
-4	<b>1100</b>	<b>1011</b>	<b>1100</b>

**Arithmetic addition:**

- Addition in signed magnitude system follows rules of ordinary arithmetic.
- EX. :  $+25 + -37 = -37 + 25 = -12$
- Thus In this, comparison of sign and magnitude and then performing either addition or subtraction.
- But in signed complement system, only addition, it does not require comparison & subtraction.
- In signed complement system, negative numbers are represents in 2's complement form and then addition to other number including their sign bits.

**Example:**    + 6    00001110 - 6 11111010 (2's complement)

$$\begin{array}{r}
 +13 \ 00001101 +13 \ 00001101 \\
 +19 \ 00010011 + 7 \ 10000011 \\
 + 6 \ 00000110 - 6 \ 11111010 \\
 -13 \ 11110011 -13 \ 11110011 \\
 - 7 \ 111111001 \quad -19 \ 11101011
 \end{array}$$

[Left significant bit is 1, so number is negative, number will be  $\rightarrow$  (2's complement of 111111001)

$$= -(000000111) = -7$$

Number will be:  $\rightarrow$  (2's complement of 11101011) =  $\rightarrow$  (00010101) =  $\rightarrow$  (19)

**Note:** If result of sum is negative, then it is in 2's complement form.

The left most significant bit of negative numbers is always 1.

- If we use signed complement system, computer needs only one hardware circuit to handle both arithmetic (signed & unsigned), so generally signed complement system is used.

**Binary Codes:**

Any discrete element of information distinct among a group of quantities can be represented with a binary code.

- n bit binary code is a group of n bits that have  $2^n$  distinct combinations of 1's and 0's with each combination representing one element of the set that is being coded.

**Example:** With 2 bits  $2^2 = 4$  elements can be coded as: 00, 01, 10, 11

With 3 bits  $2^3 = 8$  elements can be coded as:

000, 001, 010, 011, 100, 101, 110, 111

- Minimum number of bits required to code  $2^n$  distinct quantities in n.
- The bit combination of an n bit code is determined from the count in binary from 0 to  $2^n - 1$ .

**Example:** 3 bit combination

000 0

001 1

010 2

011 3

100 4

101 5

110 6

111 7

BCD code:

Binary coded decimal

- A number with k decimal digits require  $4 \times k$  bits in BCD.
- A decimal number in BCD is same as its equivalent binary number only when number is between 0 to 9.
- BCD number needs more bits than its equivalent binary.
- Example:  $(185)_{10} = (000110000101)_{BCD} = (1011101)_2$
- In BCD number, each bit is represented by its equivalent binary representation.

**Note:** BCD numbers are decimal numbers and not binary numbers, although they use bits in their representation.

- Decimal are written as 0,1,2,3,...,9 which BCD can be written as : 0000, 0001, 0010, 0011, ..., 1001

**Benefits of BCD:-**

- BCD helps to do arithmetic operation directly on decimal numbers without converting them into equivalent binary numbers.

Decimal system	BCD digits	Binary equivalent
0	0000	0000
1	0001	0001

**GATE, IES & PSUs Postal Correspondence Course**

2	0010	<b>0010</b>
3	0011	<b>0011</b>
4	0100	<b>0100</b>
5	0101	<b>0101</b>
6	0110	<b>0110</b>
7	0111	<b>0111</b>
8	1000	<b>1000</b>
9	1001	<b>1001</b>
10	00010000	<b>1010</b>
11	<b>00010001</b>	<b>1011</b>

**BCD addition:**

- If binary sum is equal to or less than 1001 (without a carry), the corresponding BCD digit is correct.
- If binary sum  $\geq 1010$ , the result is an invalid BCD digit.
- Addition of 6 = (0110)<sub>2</sub> to the binary sum converts it to the correct digit and also produces a carry as required.

**Example:**

4	0100	4	0100	8	1000
+5	+0101	+8	+1000	+9	+1001
9	1001	12	1100	17	10001
		+0110		-0110	
		10010		10111	

**Example:** Add 184 + 576 in BCD.

**Solution:**

	1	1		
	0001	1000	0100	184
	<u>0101</u>	<u>0111</u>	<u>0110+576</u>	
Binary sum	0111	10000	1010	
Add 6		<u>0110</u>	<u>0110</u>	
BCD sum	0111	0110	0000	
	7	6	0	760

The first least significant pair of BCD digits produces a BCD digits sum of 0000 and carries for the next

## GATE, IES & PSUs Postal Correspondence Course

pair of digits. The second pair of (BCD digits + carry) produces digit sum of 0110 and carry for next pair of digits. The third pair of digits plus carry produces binary sum of 0111 and does not require a correction.

- Representation of Signed decimal numbers in BCD is similar to the representation of signed number in binary.
- Sign of decimal number is represented with 4 bits :

Positive number: '0000' (0)

Negative number – '1001' (9)

.....: **Sample File**:.....

### 77 Final Selections in Engineering Services 2014.

### 6 Rank under AIR 100 in GATE 2015

Rank	Roll	Name	Branch
1	171298	SAHIL GARG	EE
3	131400	FIRDAUS KHAN	ECE
6	088542	SUNEET KUMAR TOMAR	ECE
8	024248	DEEPANSHU SINGH	EE
10	207735	VASU HANDA	ECE
22	005386	RAN SINGH GODARA	ECE
22	032483	PAWAN KUMAR	EE
29	070313	SAURABH GOYAL	EE
31	214577	PRAMOD RAWANI	EE
33	075338	DIPTIRANJAN TRIPATHY	ECE
35	003853	SHANKAR GANESH K	ECE
35	091781	KOUSHIK PAN	EE
36	052187	ANOOP A	ECE
37	008233	ARPIT SHUKLA	ECE
38	106114	MANISH GUPTA	EE
41	018349	VINAY GUPTA	ECE
44	098058	LEENA P MARKOSE	EE
45	029174	NAVNEET KUMAR KANWAT	EE

**and many more.....**

**To Buy Postal Correspondence Package call at 0-9990657855**