Number Systems - BCD Codes

Comprehensive Course on Digital Circuits

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What is the base of the numbers for the following operation to be correct?

$$\frac{(54)_b}{(4)_b} = (13)_b$$

(a) 2 (b) 4 (c) 8 (d) 16

10. The minimum decimal equivalent of the number 11C.0 is

A. 183

B. 194

C. 268

D. 269

e) 284

12

Base > 12

min Base = 13

$11C_{16} = 16^2 * 1 + 16^1 * 1 + 16^0 * 12$

α

$13^2 * 1 + 13^1 * 1 + 13^0 * 12 = 169 + 13 * 12 = 194$

Q) Determine minimum decimal eq of 328$_x$

a) 369_{10}

b) 269_{10}

c) 328_{10}

d) 2121_{0}

min $x = 9$

$3 * 9^2 + 2*9 + 8*9^0$

Given $\sqrt{(224)_r} = (13)_r$,

The value of the radix' r is:

(a) 10 (b) 8 (c) 5 (d) 6

$224_r = 13^2_r$

$2r^2 + 2r + 4 = (r+3)^2$

$2r^2 + 2r + 4 = r^2 + 9 + 6r$

$r^2 - 4r - 5 = 0$

13. Let a denote number system radix. The only values(s) of r that satisfy the equation $\sqrt{121} = 11$, is/are

A. decimal 10

B. decimal 11

C. decimal 10 and 11

D. any value > 2

min $r = 3$

$r > 2$

$\sqrt{121_r} = 11$

$121_r = 11_r^2$

$r^2 + 2r + 1 = (r+1)^2$

$(r+1)^2 = (r+1)^2$

$r > 2$

3, 4, 5 . . .

True for any 'r'

$\sqrt{121} = 11$

$121 = 11^2$

$r^2 + 2r + 1 = (r+1)^2$

$\underbrace{r^2 + 2r + 1 = r^2 + 2r + 1}$

IS true for any 'r'

16. $\sqrt{311_r} = 14_r\ r = ?$

A. any value > 4

B. 5

C. any value >5 α

D None

$311_r = 14_r^2$

$3r^2 + r + 1 = (r+4)^2$

$3r^2 + r + 1 = r^2 + 16 + 8r$

$2r^2 - 7r - 15 = 0$

$\boxed{r = 5}$

$\sqrt{64_r} = 8_r \qquad r = ?$

$\boxed{64_r = 8^2}$

By eq 10

$6r + 4 = 64$

$6r = 60 \rightarrow$ True only for $r = 10$

$r = 10$

a) $r = 10$

b) r any value ≥ 9

c) $r = 9$

d) none

12. How many 1's are present in the binary representation of

$(4\times4096) + (9\times256) + (7\times16) + 5$

A. 8 B. 9

C. 10 D. 11

$4 * 16^3 + 9 * 16^2 + 7 * 16^1 + 5$

$\downarrow$

4975_{16}

$\downarrow =$

$0100\ 1001\ 0111\ 0101_2$

$4 * 2^{12} + 9 * 2^8 + 7 * 2^4 + 5 * 2^0$

100 0000 0000 0000
1001 0000 0000
111 0000
101

100 1001 0111 0101 → 8

$r \to 10^3 * 55 = 55000$

$10^5 * 47 = 4700000$

$$r^n * Num = Num\overbrace{000\cdots0}^{n}r$$

$2^3 * 5 = 40$

$2^3 * (101)_2 = 101000_2$

$96 = 2^4 * 6$

$2^4 * 110_2 = 1100000_2$

$2^5 * 3$

1100000

Q) Determine no of 1's in binary equivalent of

$8192 * 6 + 4096 * 7 + 512 * 4 + 256 * 2 + 16 * 1$

$2^{13} * 6 + 2^{12} * 7 + 2^{9} * 4 + 2^{8} * 2 + 2^{4} * 1$

a) 7

b) 8

c) 9

d) 10

e) 6

6

$14 + 26 = 40$

```
 1  1 0   0   0000  0000  0000
    1 1   1   0000  0000  0000
              1000  0000  0000
                10  0000  0010
                         10000
 1 0 0 1 1 1 0 1 0  0001  0000
```

11. The number of digit 1 present in the binary representation of 3×512+7×64+5×8+3 is $\rightarrow 3 * 8^3 + 7 * 8^2 + 5 * 8^1 + 3 * 8^0$

A. 8 B. 9

C. 0 D. 12

3753_8

011 111 101 011

$3 * 2^9 + 7 * 2^6 + 5 * 2^3 + 3$

```
11 0000 00000
   1110 000000
        101000
            11
--------------
11 111 101 011
```

Consider the number given by the decimal expression.

$$16^3 \times \overset{1001}{9} + 16^2 \times \overset{0111}{7} + 16 \times \overset{0101}{5} + \overset{0011}{3} = 9753$$

1001 0111 0101 0011

The number of 1's in the unsigned binary representation of the number is

a) 6 b) 7 c) 8 d) 9

r's Compliment

&

$(r-1)$'s Compliment

r = base,

→ A + B

↓

Adder

A − B

Subr

Adder

↓

Save

Hardware

A − B = A + 2's Comp of 'B'

Binary

A − B = A + 2's Comp of 'B'

Ex:- $r = 10$

$$\begin{array}{r} 80 \\ -16 \\ \hline 64 \\ \hline \end{array}$$

$$\begin{array}{r} 100 \\ -16 \\ \hline 84 \end{array} \rightarrow 10^2 - 16$$

$$\begin{array}{r} 80 \\ 84 \\ \hline 1\ 64 \\ \hline \end{array}$$

↑ neglect

$$\begin{array}{r} 80 \\ -16 \end{array} \quad \begin{array}{r} 80 \\ \boxed{\begin{array}{r} 100 \\ -16 \end{array}} \\ 1\ 64 \end{array}$$

↑ neglect

$$\begin{array}{r} 452 \\ -135 \\ \hline 317 \\ \hline \end{array}$$

$$\begin{array}{r} 1000 \\ -135 \\ \hline 865 \\ \hline \end{array} \rightarrow r' \text{ comp} \rightarrow 10^3 - 135$$

$$\begin{array}{r} 452 \\ +865 \\ \hline 1\ 317 \\ \hline \end{array}$$

↑ neglect

r's comp $= r^N - \text{NUM}$ → $A - B = A + r$'s comp of 'B'

N = no of digits

$$2^3 = 1000_2$$

$$2^4 = 10000_2$$

$$2^5 = 100000_2$$

$$10^3 = 1000_{10}$$

$$10^5 = 100000_{10}$$

$$r^n = 1\underbrace{0000\cdots0}_{n}$$

$$2^3 - 1 = 7 = 111_2$$

$$2^4 - 1 = 15 = 1111_2$$

$$10^3 - 1 = 1000 - 1 = 999_{10}$$

$$10^4 - 1 = 9999_{10}$$

$$r^N - 1 = \overbrace{(r-1)(r-1)\cdots(r-1)}^{N\text{-times}}$$

N - No of Digits

r's compliment $\doteq$ r^N - Num $= \underbrace{1000 \cdots 0}_{N}$ - Num

$(r-1)$'s compliment $\doteq$ $r^N - 1$ - Num $= (r-1)(r-1) \cdots (r-1)$ - Num

r's comp $= (r-1)$'s comp $+ 1$

Example:- Decimal $\Rightarrow r = 10$; **Ex:-** $N = 4$ Num:- 1234_{10}

9's compliment:- $10^4 - 1 - \text{NUM} =$

$$\begin{array}{r} 9999 \\ -\ 1234 \\ \hline 8765_{10} \end{array}$$

10's comp:- $10^4 - \text{NUM} =$

$$\begin{array}{r} 10000 \\ -\ 1234 \\ \hline 8766 \end{array} \quad \text{(or)} \quad \begin{array}{r} 8765 \\ +\ 1 \\ \hline 8766 \end{array}$$

Ex :-   Octal $r = 8$

Num :- 1375_8

7's Comp :- $8^4 - 1 - \text{Num} = 7777_8$

$$\begin{array}{r} 7777_8 \\ -1375_8 \\ \hline 6402_8 \\ \hline \end{array}$$

8's Comp :-

$$\begin{array}{r} 6402 \\ +1 \\ \hline 6403 \\ \hline\hline \end{array}$$

Ex :- $r = 2$; Binary

Num :- 1010

1's compliment :- $2^n - 1 - \text{Num} =$

$$\begin{array}{r} 1111_2 \\ -\,1010_2 \\ \hline 0101 \end{array}$$

1's comp of $\overline{1010} = 0101$

$$\boxed{\begin{aligned} A - B &= A + 2\text{'s comp } B \\ &= A + \underbrace{r^N - B} \end{aligned}}$$

2's comp :-

$$\begin{array}{r} 0101 \\ +1 \\ \hline 0110 \end{array}$$

Hexa

$r = 16$; Num $= 1A2F_{16}$

F's compl $=$

$$\begin{array}{r} FFFF \\ -1A2F \\ \hline E5D0_{16} \end{array}$$

16's Comp $=$

$$\begin{array}{r} E5D0 \\ +1 \\ \hline E5D1_{16} \end{array}$$

FFFF
2BFD
D402

F's complement of $(2BFD)_{hex}$ is

(a) E304

(b) D403

(c) D402

(d) C403

(r-1)'s comp

99.999

The 9's complement of $(25.639)_{10}$ is

74.36 r

(a) 74.360

(b) 0.6732

(c) 6.732

(d) 7.436

BCD Codes

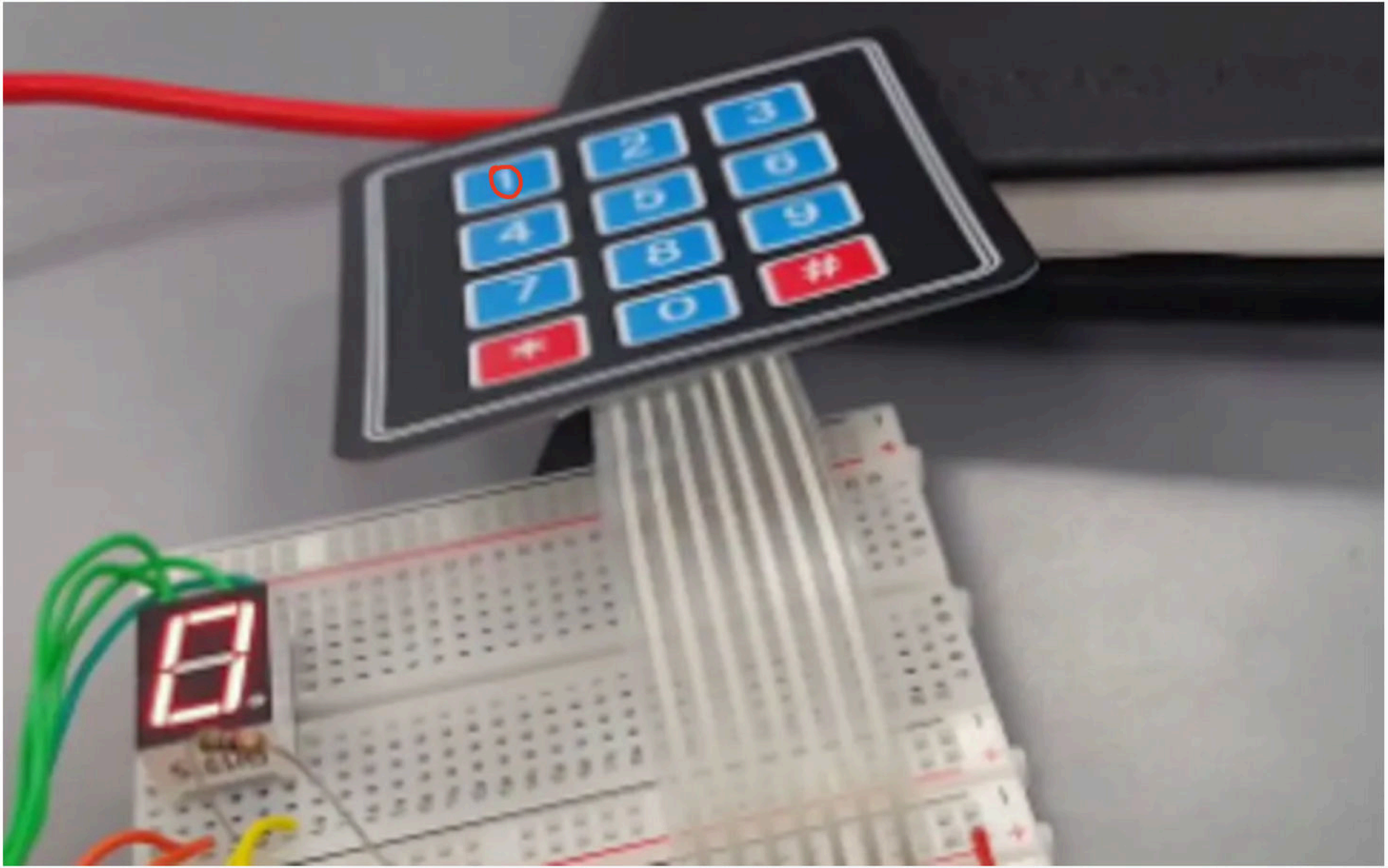
num : 25 : 11001_2 → Binary

2 5

0010 0101$_2$ → Packed BCD → Binary Coded Decimal.

2 5

0000 0010 0000 0101$_2$ → Unpacked BCD

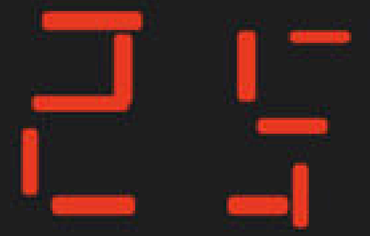

1
2
3
4
5
6
7
8
9
*
0
#

	a	b	c	d	e	f	g
1	0	1	1	0	0	0	0
2	1	1	0	1	1	0	1
⋮			⋮				
9	1	1	1	1	0	1	1

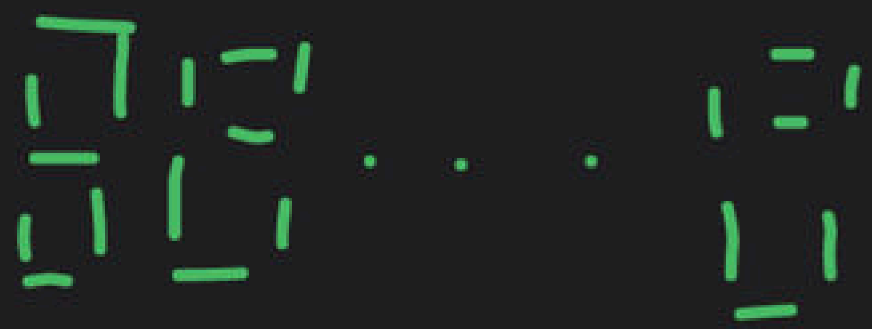
'10'
Diff
codes

If 2-digits

 → 00 to 99 } 100 Codes

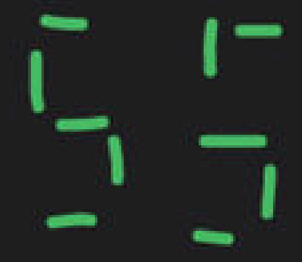


10-digit Display

 → 00 - - 0 to 99 . . . 9 } 10^{10} Codes

Deci → Binary

55 → 111001 → Binary



55 → $\underbrace{0101}\ \underbrace{0101}$ → Treat Every Digit Seperately

Each digit 0-9

↓

only 10 Codes

Binary

0 → 0

⋮

9 → 1001

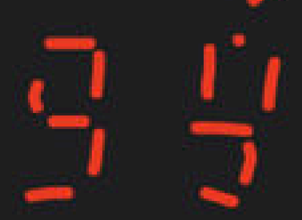
10 → 1010

11 → 1011

⋮

19 → 10011

⋮

99 → 1100011 → 

BCD

0 → 000

⋮

9 → 1001

10 → 0001 0000

⋮

19 → 0001 1001

⋮

99 → 1001 1001

BCD CODES:

weighted (positional value) — 8421, 2421, 84-2-1

unweighted (no positional value) — excess-3

Decimal	8421	2421	84-2-1	excess-3
0	0000	0000	0000	0011
1	0001	0001	0111	0100
2	0010	0010	0110	0101
3	0011	0011	0101	0110
4	0100	0100	0100	0111
5	0101	1011	1011	1000
6	0110	1100	1010	1001
7	0111	1101	1001	1010
8	1000	1110	1000	1011
9	1001	1111	1111	1100

8	4	-2	-1
0	0	0	0
0	1	1	1
0	1	1	0
0	1	0	1
0	1	0	0
1	0	1	1
1	0	1	0
1	0	0	1
1	0	0	0
1	1	1	1

BCD CODES:

Decimal	8421	2421	84-2-1	excess-3
0	0000	0000	0000	0011
1	0001	0001	0111	0100
2	0010	0010	0110	0101
3	0011	0011	0101	0110
4	0100	0100	0100	0111
5	0101	1011	1011	1000
6	0110	1100	1010	1001
7	0111	1101	1001	1010
8	1000	1110	1000	1011
9	1001	1111	1111	1100

BCD CODES:

Not self comp

self complimentory codes

Decimal	8421	2421	84-2-1	excess-3
0	0000	0000	0000	0011
1	0001	0001	0111	0100
2	0010	0010	0110	0101
3	0011	0011	0101	0110
4	0100	0100	0100	0111
5	0101	1011	1011	1000
6	0110	1100	1010	1001
7	0111	1101	1001	1010
8	1000	1110	1000	1011
9	Seq 1001	1111	1111	1100

Self Complimentary codes :- 9's comp = 1's comp

Ex :- Excess-3 :- 5 → 1000 ⟶ 1's comp of '5' :- $\overline{1000}$ = 0111 //

9's comp of '5' ⇒ 9 − 5 = 4 ⇒ 0111 //

In Excess-3

Excess-3 is self complimentary & also sequential code

i.e, if we add '1' to prev num we get next num.

In self comp code sum of weights = 9

Code	Weighted	Sequential	Self Comp
8421	✓	✓	✗
2421	✓	✗	✓
84-2-1	✓	✗	✓
Excess-3	✗	✓	✓

8421

5 $\div$ 0 1 0 1

7 $\div$ 0 1 1 1

8 $\rightarrow$ 1 0 0 0

2 4 2 1

6 $\rightarrow$ 1 1 0 0

$\vdots$

4 4 5 3

1000 100 10 1

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▲ 1 • Asked by Rishav

One simple doubt....in complements why we take

r^n-1-N=(r_1)(r-1).....-Num

$10^5 - Num = 100000 - Num$

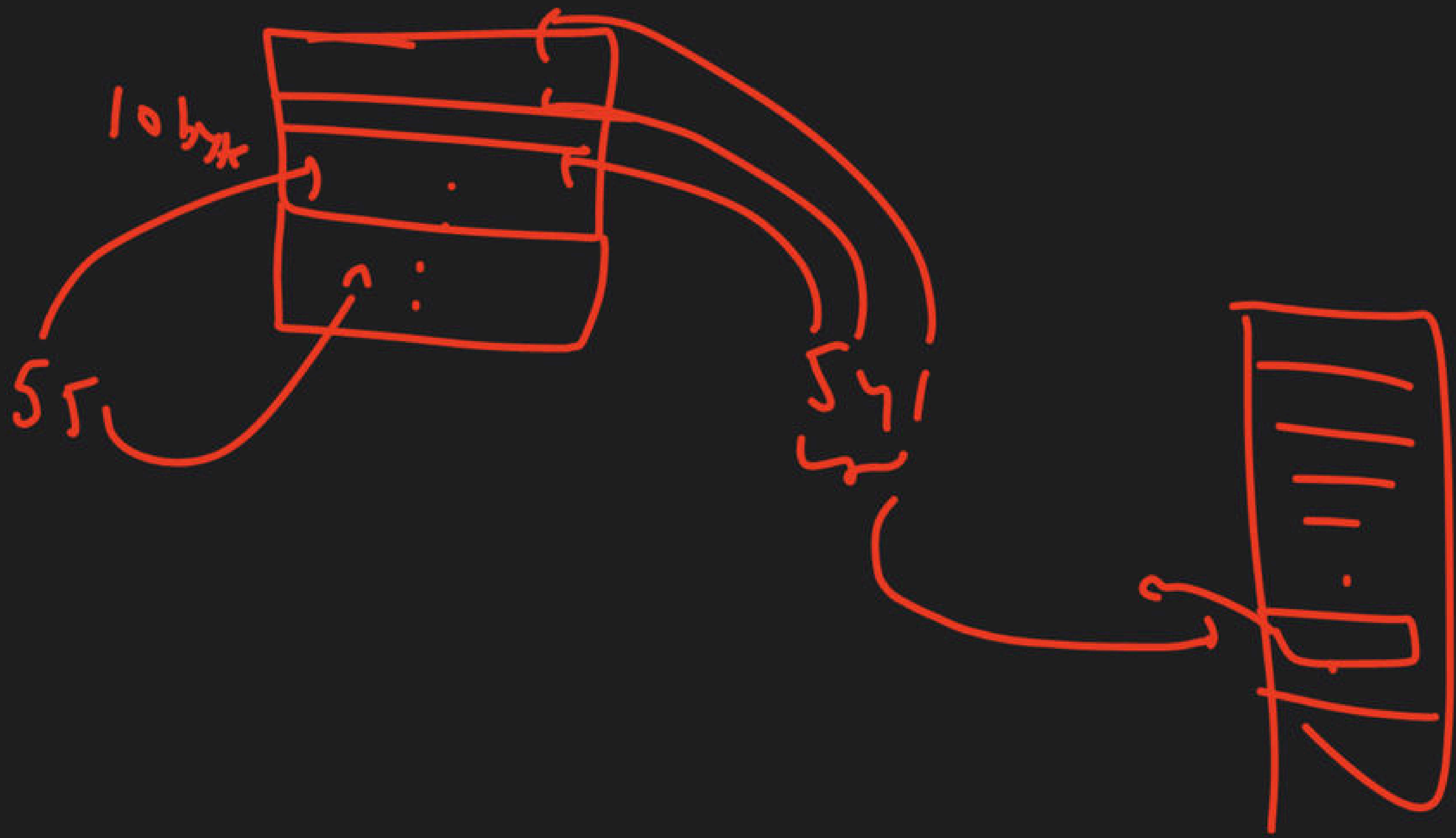
$10^5 - 1 = 99999 - Num$

Bin

$2^4 - Num = 10000 - Num$

$2^4 - 1 - Num = 1111 - Num$

$$\boxed{(r-1)\ldots(r-1) - Num}$$


10 byte
55
541