AKTU B.Tech II-Year

GATEWAY CLASSES

EC & EC Allied

DSD : Digital System Design

Unit-1 Lec-3



Avinash Sir

Today's target

- Signed magnitude representation
- Binary Codes
- PYQ
- DPP

Gateway Classes

AKTU : *DIGITAL SYSTEM DESIGN (BEC-302)* Syllabus

UNIT-1 : Logic simplification and combinational logic design

- Number Systems
- Binary arithmetic
- Signed magnitude representation
- Binary codes, code conversion
- Review of Boolean algebra and Demorgans theorem
- SOP & POS forms
- Canonical forms
- Karnaugh maps up to 5 variables
- Tabulation method.

Gateway Classes

Signed magnitude representation

$2^n = 2^8 = 256$
(0 - 255)
-127 to +127

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It is a method for storing signed binary numbers (numbers that can be either + or -). In this system, one bit of the binary number is dedicated to the sign, and the remaining bits represent the number's magnitude (its absolute value).

Sign Bit: The most significant bit (MSB), or the leftmost bit, is the sign bit. A 0 for +ve & 1 For – ve Number.

Magnitude Bits: The remaining bits represent the magnitude of the number in standard binary.

For example, using an 8-bit system:

Sign bit

- The decimal number +53 would be represented as 0 0 1 1 0 1 0 1
- The decimal number −53 would be represented as 1 0 1 1 0 1 0 1.

Range :- For a 8-digit number range is 0 to 255. But in signed magnitude representation range will be -127 to +127.

Hence largest negative number is -127 or 1 1 1 1 1 1 1 1 &

largest positive number is +127 or 0 1 1 1 1 1 1 1

Gateway Classes

Signed Complement Numbers

When representing negative numbers in binary, two common systems are used:

1's Complement Representation

2's Complement Representation

Both methods allow positive and negative numbers to be stored in binary format.

Gateway Classes

1. *1's Complement*

Positive numbers → *same as normal binary.*

Negative numbers → *take the binary of the absolute value, then invert all bits (0 → 1, 1 → 0).*

Example (with 4-bit system):

Represent +5 and –5.

+5 in binary (4-bit) = 0101

–5 → take 5 (0101), invert → 1010

2's Complement Representation

Positive numbers: written as normal binary.

Negative numbers: Take binary of positive number.

Find 1's complement (invert).

Add 1.

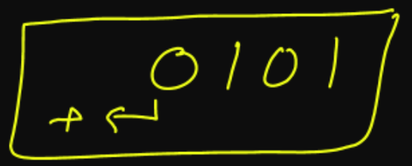
Example (using 4 bits): +5 = 0101

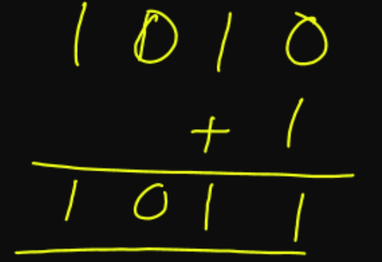
To get –5:

Invert → 1010

Add 1 → 1010 + 1 = 1011

So –5 = 1011 (2's complement form).



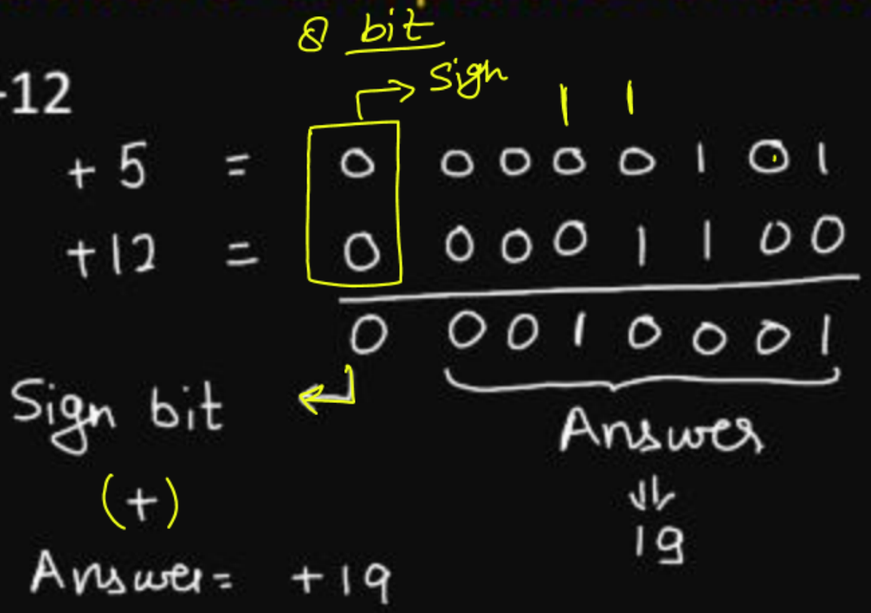


Gateway Classes

Addition of signed Numbers

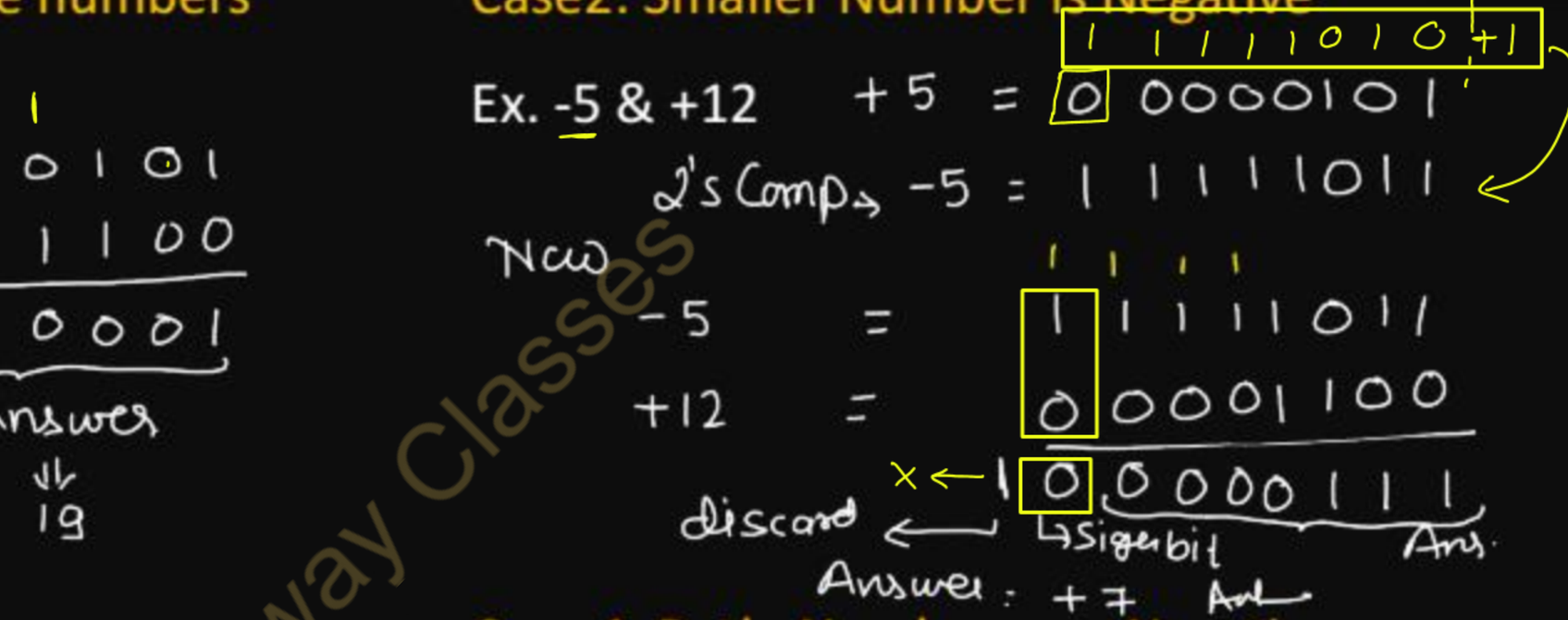
Case-1 : Addition of both positive numbers

Ex. +5 & +12



Case2: Smaller Number is Negative

Ex. -5 & +12



Case3: Large Number is Negative

Ex. + 5 & -12

Case 4: Both Numbers are Negative

Ex. -5 & - 12

Gateway Classes

+5 & -12

+5 → 0 0000101

-12 → 2's Comp of +12

+12 → 0 0001100

1's Comp → 1 1 1100 1 1

+ 1

2's Comp = 1 1 1 1 0 1 0 0 → -12

+5 → 0 0000101

-12 → 1 1 1 10100

1 1 1 1 1 0 0 1

Sign bit Answer (-)

2's Comp of Answer

∴ Final Answer 1 1 1 1 0 0 1 → 2's comp.

− 1

1 1 1 1 0 0 0 → 1's Comp

0 0 0 0 1 1 1

final Answer −7

Ex:

−5 , −12

↳2's ↳2's

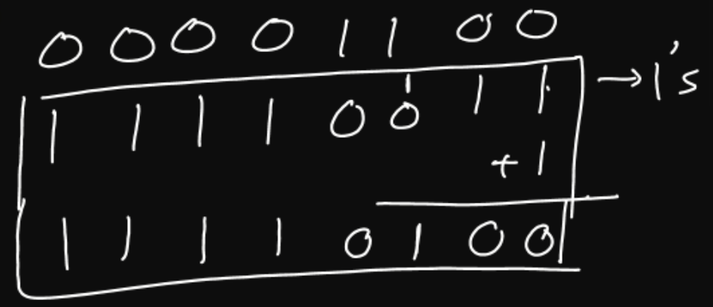
Sign-①

Answer 2's Comp

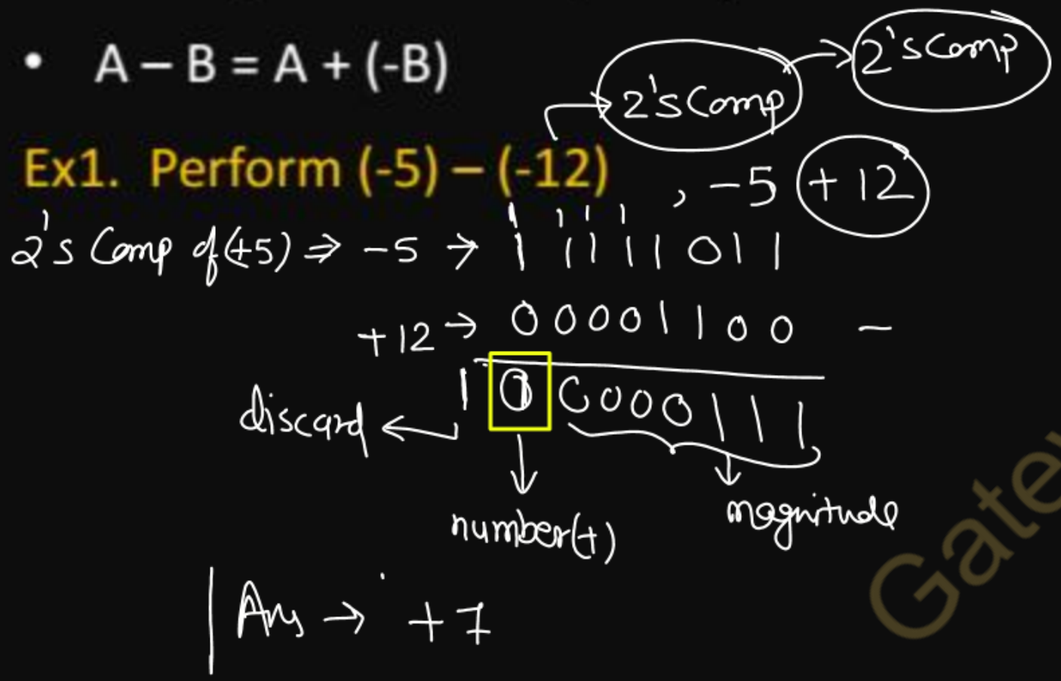
Gateway Classes

Subtraction of signed Numbers

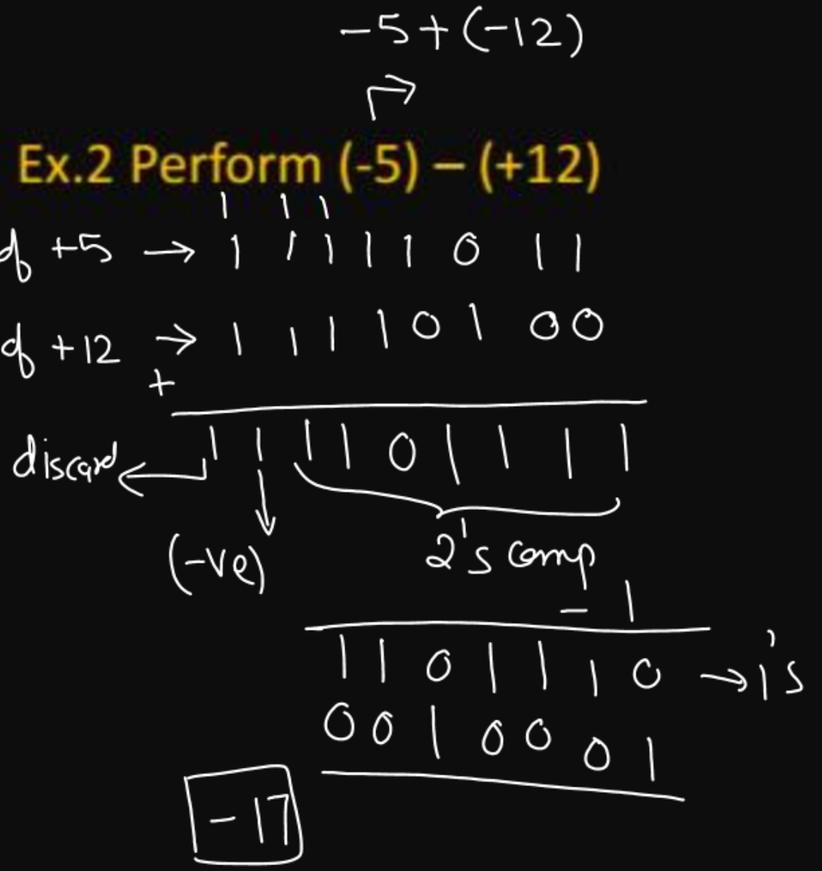
- Take 2's complement of subtrahend
- Add it to the minuend (including sign bits).
- A carry out of the sign bit position should be discarded.
- A – B = A + (-B)



Ex1. Perform (-5) – (-12)



Ex.2 Perform (-5) – (+12)



Gateway Classes

Binary Codes

- A binary code is a system of representing information (numbers, characters, symbols) using 0s and 1s.
- Each element of the information is represented by a group of bits (code word).
- Used in digital systems, computers, and communication.

Types of Binary Codes

(A) Weighted Codes

Each bit position has a fixed weight.

Ex. BCD code, 8421 code , 2421 code

(B) Non-Weighted Codes

Do not use positional weights.

Gray Code, Excess Code

(C) Alphanumeric Codes

Represent letters, numbers, and symbols.

ASCII Code , EBCDIC code

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Binary Codes

BINARY CODES - FLOW CHART

BINARY CODES

Weighted Codes	Non-Weighted Codes	Alphanumeric Codes	Error Control Codes
• BCD (8421)	• Excess-3	• ASCII (7/8-bit)	• Parity Bit (Error Detect)
• 2421 Code	• Gray Code	• EBCDIC (8-bit)	• Hamming Code (Detect + Correct)

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BCD Code (8421 code)

Ten + 6 → invalid

- BCD (Binary Coded Decimal)Decimal digits (0–9) are represented by 4-bit binary numbers.
- But with 4 bits we can represent 0000 to 1111 (16 numbers). In BCD remaining six numbers (1010 to 1111) are invalid.

Conversion of Decimal to BCD

(1) 78 (ii) 236

7 → 0111
8 → 1000

BCD Code
→ 0111 1000

2 → 0010
3 → 0011
6 → 0110

BCD code
0010 0011 0110

Decimal	Binary	BCD (8421)
0	0000	0000
1	0001	0001
2	0010	0010
3	0011	0011
4	0100	0100
5	0101	0101
6	0110	0110
7	0111	0111
8	1000	1000
9	1001	1001
10	1010	0001 0000
11	1011	0001 0001
12	1100	0001 0010
13	1101	0001 0011
14	1110	0001 0100
15	1111	0001 0101

Same as Binary

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Advantages of BCD Code

- Easy Conversion → Direct conversion between decimal digits and binary form.
- Human-friendly → Representation is closer to decimal, making it easier for humans to read.
- Reduces coding errors → Each decimal digit is separately encoded, making debugging easy.

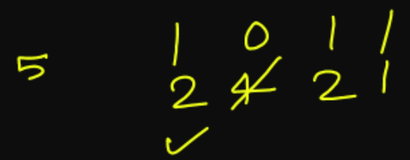
Disadvantages of BCD Code

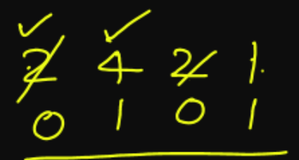
- Not space-efficient → Uses 4 bits for only 10 digits (0000–1001). Six combinations (1010–1111) are unused.
- Slower arithmetic → Addition and subtraction are more complex compared to pure binary and having different rules
- Less memory-efficient → Compared to pure binary, it consumes more storage.

Applications of BCD Code

- Digital Displays → 7-segment displays in calculators, digital clocks, counters.
- Financial Calculators → Used where decimal accuracy is needed (avoids binary rounding errors).
- Digital Systems → Where decimal data input/output is common (e.g., billing machines, digital meters).

Gateway Classes





2421 code

- Weighted code with weights 2,4,2,1.
- Two position has the same weights
- There could be two possible bit pattern for some decimal numbers
- But we can use only one

- Ex. 5 → 1011 (2+0+2+1=5).

Other codes are 3321 , 4221, 5211, 5421, 6311, 7421,

Decimal	Binary	(2421 Code)
0	0000	0 0 0 0
1	0001	0 0 0 1
2	0010	0 0 1 0
3	0011	0 0 1 1
4	0100	0 1 0 0
5	0101	1 0 1 1
6	0110	1 1 0 0
7	0111	1 1 0 0
8	1000	1 1 1 0
9	1001	1 1 1 1

Gateway Classes

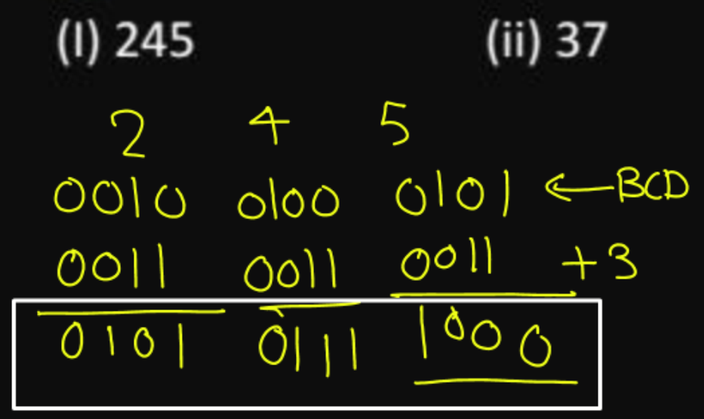
Excess 3 code

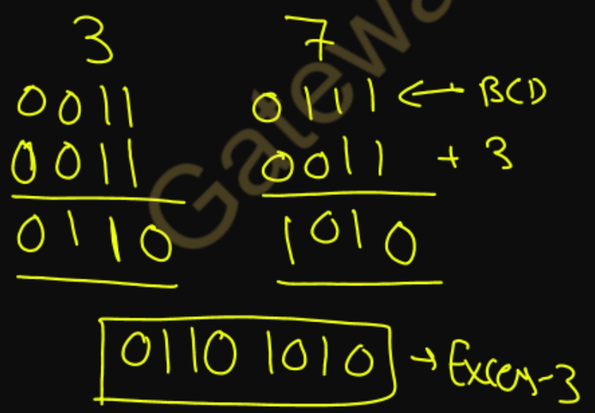
- Derived from BCD by adding 3 (0011) to each digit.
- Example:

  Decimal 5 → BCD (0101) + 0011 = 1000
- Self-complementing code (9's complement easy).

Ex:-

(I) 245 (ii) 37



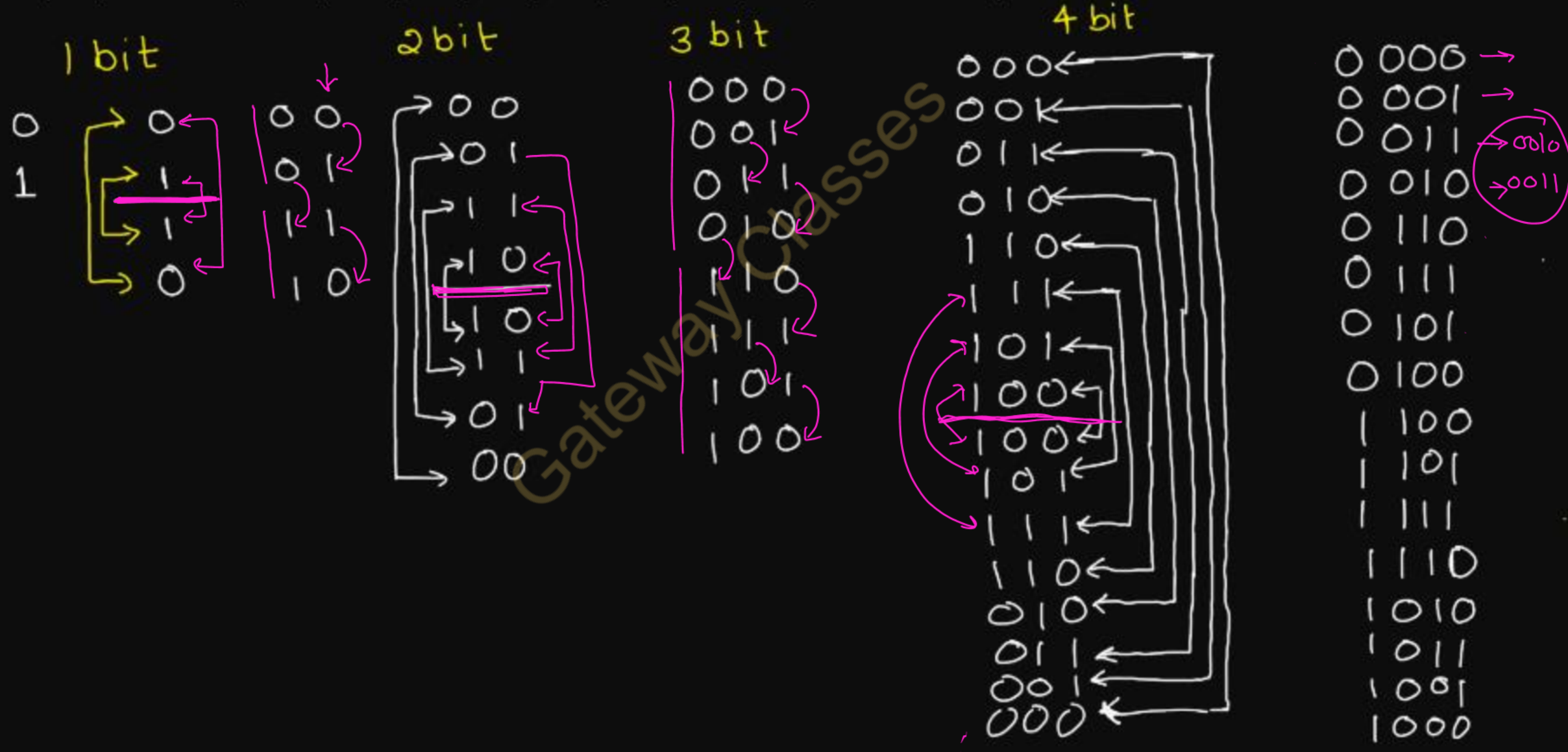


Decimal	BCD	Excess 3
0	0000 +0011 (3)	0011
1	0001	0100
2	0010	0101
3	0011	0110
4	0100	0111
5	0101	1000
6	0110	1001
7	0111	1010
8	1000	1011
9	1001	1100

Gateway Classes

Gray Code (Reflected Binary Code)

- Consecutive numbers differ by only one bit (minimizes errors). Also known as unit distance code or cyclic codes
- Example (3-bit Gray code):000, 001, 011, 010, 110, 111, 101, 100Used in position encoders.



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Advantages of Gray Code

- Error Reduction → Only 1 bit changes, minimizing errors in transmission.
- Simple hardware implementation → Especially useful in position sensors.
- Used in Karnaugh Maps (K-Maps) → Simplifies logic minimization since adjacent cells differ by only 1 bit.

Disadvantages of Gray Code

- Not suitable for arithmetic → Cannot directly add or subtract in Gray code.
- Conversion needed → Must convert to/from binary for arithmetic operations.
- More complex for large systems compared to binary.

Applications of Gray Code

- Rotary and Linear Encoders → To measure shaft positions without errors.
- Karnaugh Maps (K-Maps) → For minimizing Boolean expressions.
- Error Detection → Reduces chances of errors during bit transitions in communication.
- Digital Systems → Used where precision and error-free transitions are important.

Gateway Classes

Digital System Design

UNIT -1 L 3 : DPP

Q. Perform following operation as indicated.

I. Add using Sign numbers 7 & 12 (ii) 9 & -13

II. Subtract using Sign numbers -13 & (-14)

III. Convert 243 in

BCD code, Excess 3 code , 2421 code

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Empowering Learners, Transforming Futures

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Thank You

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