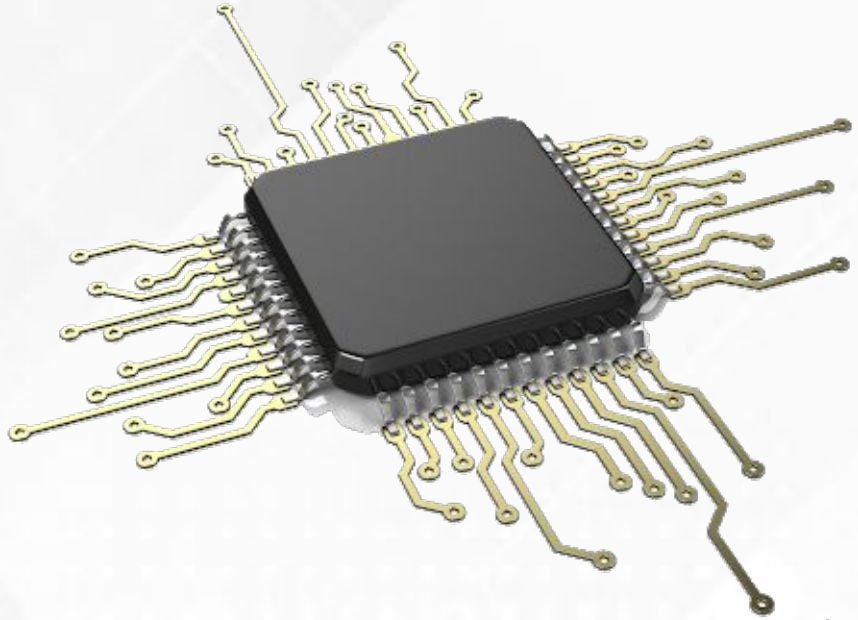
Computer Organization & Architecture
(COA)
GTU # 3140707

Dedicated Faculty, Committed Education
Darshan
Institute of Engineering & Technology

Unit-7

Computer Arithmetic



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Outline

- Addition and Subtraction
- Multiplication Algorithms (Booth Multiplication Algorithm)
- Decimal Arithmetic Unit
- Questions asked in GTU exam

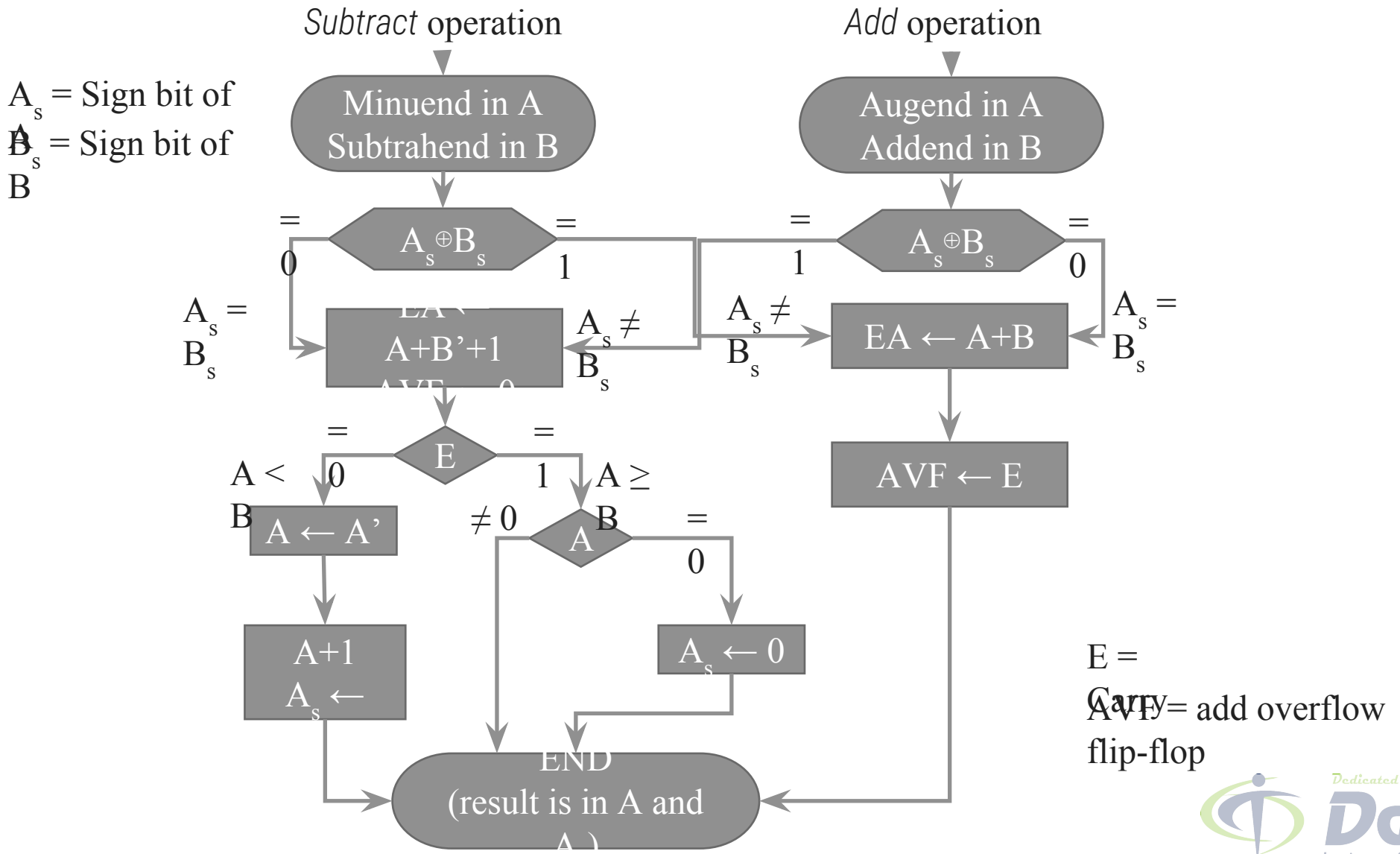
Addition and Subtraction

Section - 1

Addition and Subtraction

Operation	Add Magnitudes	Subtract Magnitudes		
		When A > B	When A < B	When A = B
(+A) + (+B)	+ (A + B)			
(+A) + (-B)		+ (A - B)	- (B - A)	+ (A - B)
(-A) + (+B)		- (A - B)	+ (B - A)	+ (A - B)
(-A) + (-B)	- (A + B)			
(+A) - (+B)		+ (A - B)	- (B - A)	+ (A - B)
(+A) - (-B)	+ (A + B)			
(-A) - (+B)	- (A + B)			
(-A) - (-B)		- (A - B)	+ (B - A)	+ (A - B)

Flowchart for Addition & Subtraction



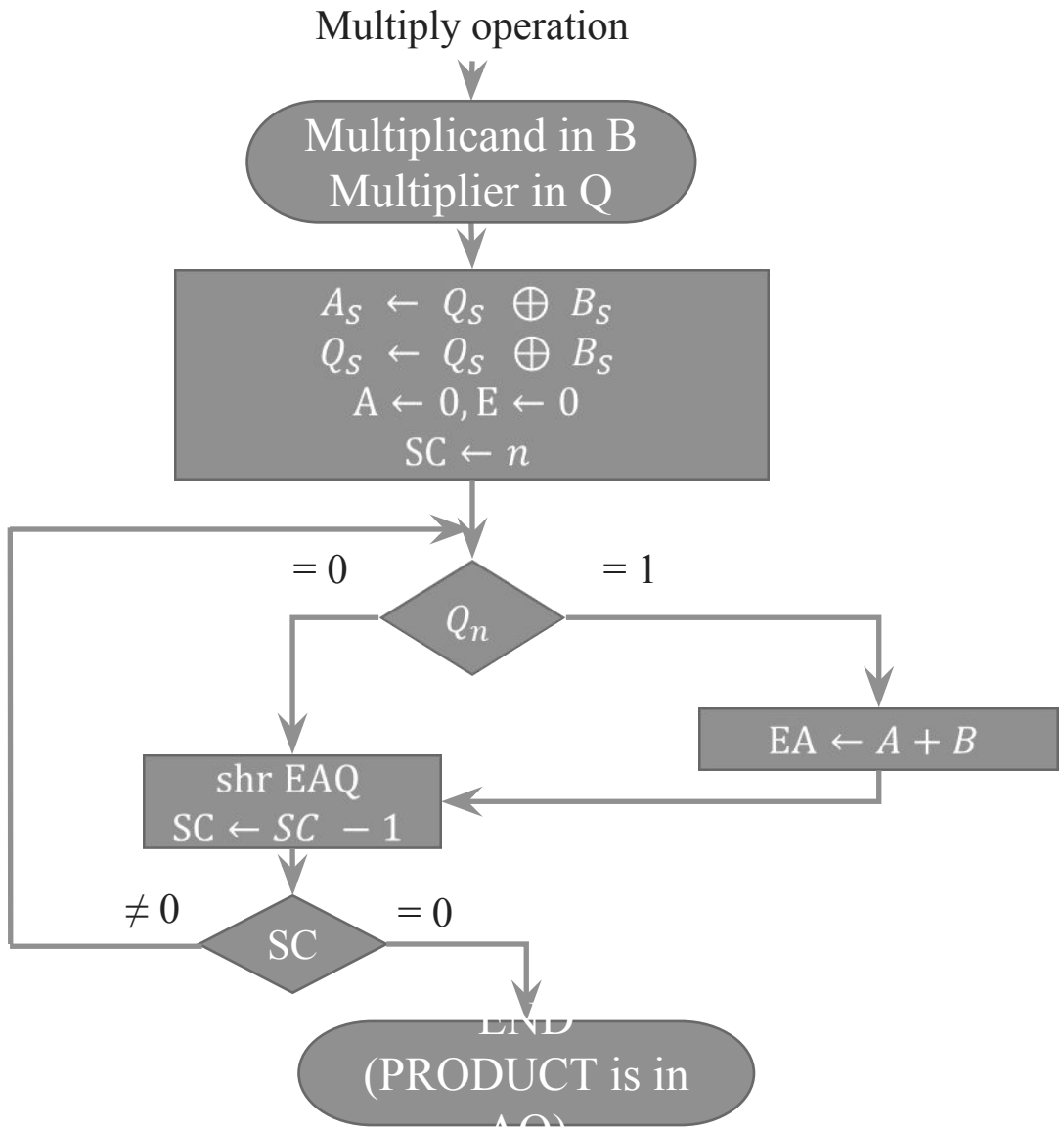
Multiplication Algorithms (Booth Multiplication Algorithm)

Section - 2

Multiplication

- Traditional way of binary multiplication

23	10111
x19	x 10011
	10111
	10111
	00000
	00000
	10111
437	110110101



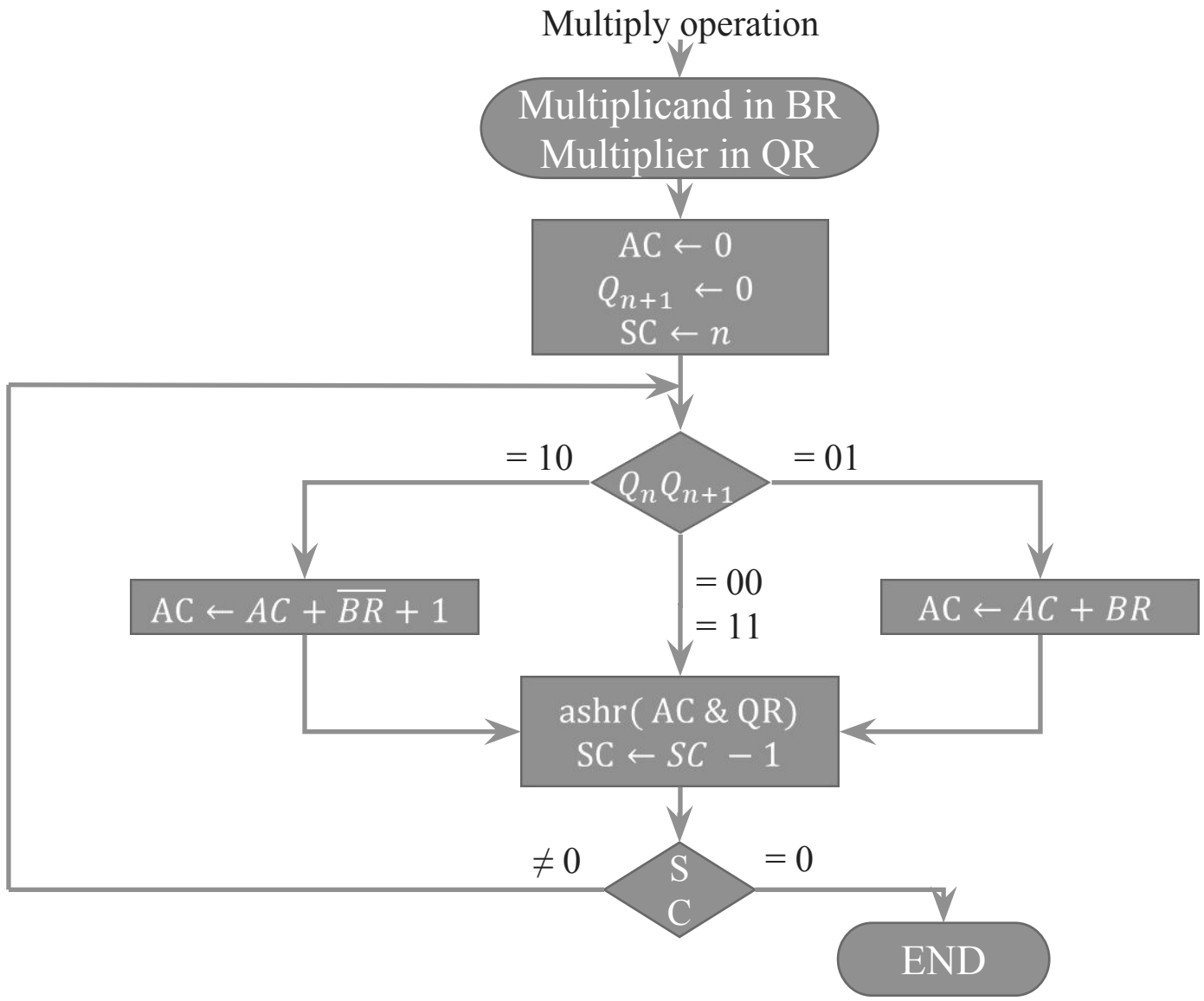
Perform 23 x 19

Multiplicand B = 10111	**E**	**A**	**Q**	**SC**
Multiplier in Q	0	00000	10011	101
Q_n = 1; add B		10111		
First partial product	0	10111		
Shift right EAQ	0	01011	11001	100
Q_n = 1; add B		10111		
Second partial product	1	00010		
Shift right EAQ	0	10001	01100	011
Q_n = 0; shift right EAQ	0	01000	10110	010
Q_n = 0; shift right EAQ	0	00100	01011	001
Q_n = 1; add B		10111		
Fifth partial product	0	11011		
Shift right EAQ	0	01101	10101	000
Final product in AQ = 0110110101				

Multiply (-9) x (-13) using Booth Algorithm

		Initial	00000	10011	0	101
1	0	Subtract BR	01001			
			01001			
		ashr	00100	11001	1	100
1	1	ashr	00010	01100	1	011
0	1	Add BR	10111			
			11001			
		ashr	11100	10110	0	010
0	0	ashr	11110	01011	0	001
1	0	Subtract BR	01001			
			00111			
		ashr	00011	10101	1	000

Booth Multiplication Algorithm



Decimal Arithmetic Unit

Section - 3

BCD Adder

		1	
97		1001	0111
+ 99	+	1001	1001
196	1	0011	0000
		+011	+011
	1	0 1001	0 0110

Both groups generate carry

Add 0110 to each

If codes are illegal or carry is generated in the group then we add 0110 to that particular group

- Two BCD digits are applied to 4-bit binary adder which produce result ranging from 0 to 19 i.e. 9 + 9 + 1 = 19
- Output sum of two decimal numbers must be represented in BCD.
- Problem is to find rule by which binary number is to be converted to correct BCD

BCD Adder

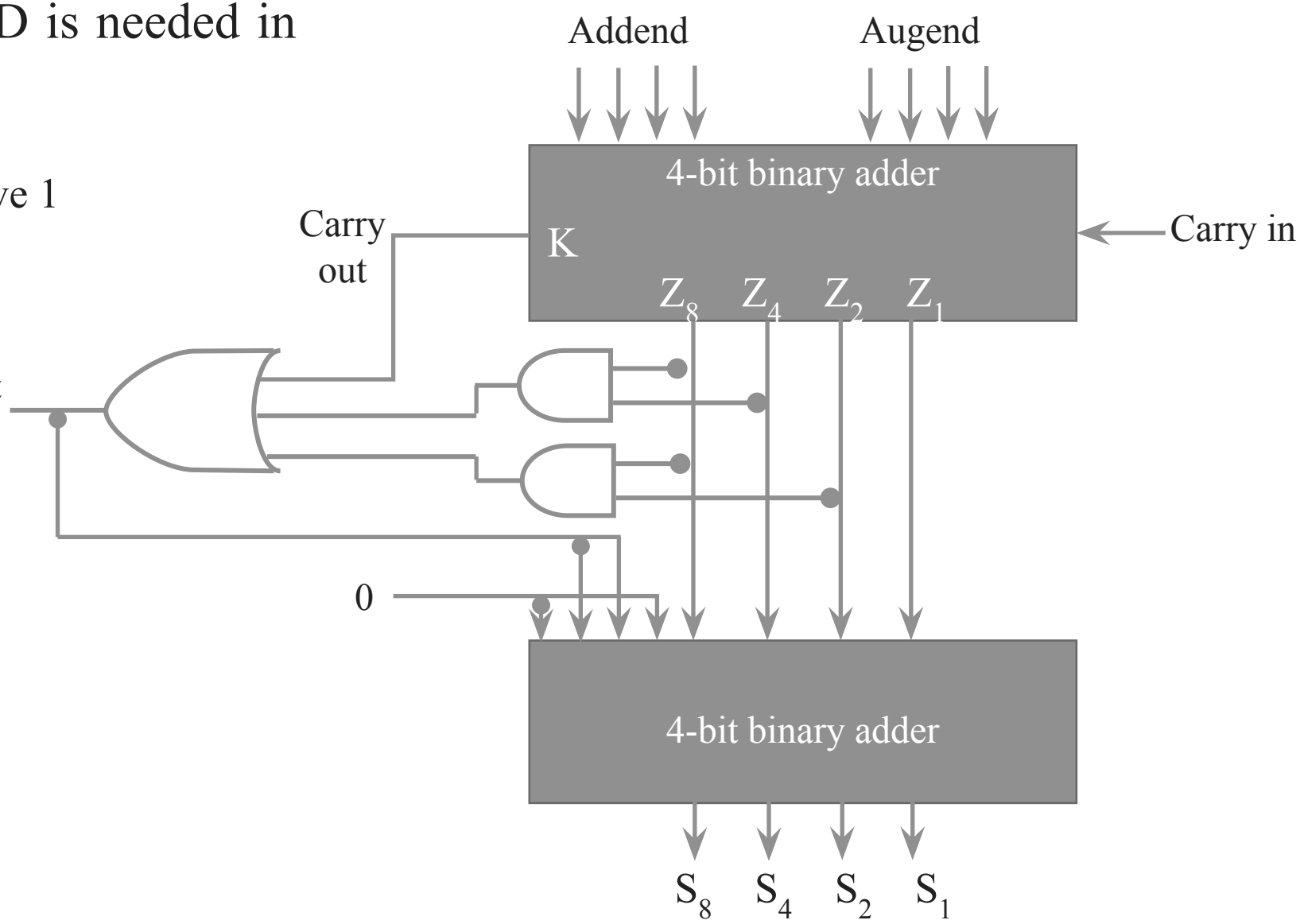
Binary Sum					BCD Sum					
K	Z_8	Z_4	Z_2	Z_1	C	S_8	S_4	S_2	S_1	Decimal
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0	1	1
0	0	0	1	0	0	0	0	1	0	2
0	0	0	1	1	0	0	0	1	1	3
0	0	1	0	0	0	0	1	0	0	4
0	0	1	0	1	0	0	1	0	1	5
0	0	1	1	0	0	0	1	1	0	6
0	0	1	1	1	0	0	1	1	1	7
0	1	0	0	0	0	1	0	0	0	8
0	1	0	0	1	0	1	0	0	1	9

Binary Sum					BCD Sum					
K	Z_8	Z_4	Z_2	Z_1	C	S_8	S_4	S_2	S_1	Decimal
0	1	0	1	0	1	0	0	0	0	10
0	1	0	1	1	1	0	0	0	1	11
0	1	1	0	0	1	0	0	1	0	12
0	1	1	0	1	1	0	0	1	1	13
0	1	1	1	0	1	0	1	0	0	14
0	1	1	1	1	1	0	1	0	1	15
1	0	0	0	0	1	0	1	1	0	16
1	0	0	0	1	1	0	1	1	1	17
1	0	0	1	0	1	1	0	0	0	18
1	0	0	1	1	1	1	0	0	1	19

BCD Adder

- Correction from binary to BCD is needed in following conditions
  - K = 1
  - Z_8 and Z_4 or Z_8 and Z_2 must have 1

$$C = K + Z_8Z_4 + Z_8Z_2$$



Questions asked in GTU exam

Section - 4

Questions asked in GTU exam

1. Explain Booth multiplication algorithm for multiplying binary integers in signed 2's complement representation.
2. Draw and explain flowchart for addition and subtraction operations with sign-magnitude data.
3. Explain BCD Adder with its block diagram.
4. Develop an algorithm for multiplication of two binary numbers, which are stored as per floating point representation.
5. Draw flowchart hardware multiplication algorithm and explain it.