Solution

Marks

Q. 1 Convert decimal +61 and +27 to binary using the signed-2's complement representation and enough digits to accommodate the numbers. Then perform the binary equivalent of (+27) + (-61), (-27) + (+61) and (-27) + (-61). Convert the answers back to decimal and verify that they are correct. **6**

Solution:

$(+61)_{10} = (00111101)_2 \Rightarrow (-61)_{10} = (11000011)_2$
$(+27)_{10} = (00011011)_2 \Rightarrow (-27)_{10} = (11100101)_2$

a. (+27) + (-61)

$(+27)_{10}$	$(0\ 0\ 0\ 1\ 1\ 0\ 1\ 1)_2$
$+\ (-61)_{10}$	$(1\ 1\ 0\ 0\ 0\ 0\ 1\ 1)_2$
$=\ (-34)_{10}$	$(1\ 1\ 0\ 1\ 1\ 1\ 1\ 0)_2$

b. (-27) + (+61)

$(-27)_{10}$	$(1\ 1\ 1\ 0\ 0\ 1\ 0\ 1)_2$
$+\ (+61)_{10}$	$(0\ 0\ 1\ 1\ 1\ 1\ 0\ 1)_2$
$=\ (+34)_{10}$	$\cancel{1}\ (0\ 0\ 1\ 0\ 0\ 0\ 1\ 0)_2$

c. (-27) + (-61)

$(-27)_{10}$	$(1\ 1\ 1\ 0\ 0\ 1\ 0\ 1)_2$
$+\ (-61)_{10}$	$(1\ 1\ 0\ 0\ 0\ 0\ 1\ 1)_2$
$=\ (-88)_{10}$	$\cancel{1}\ (1\ 0\ 1\ 0\ 1\ 0\ 0\ 0)_2$

Q. 2 At the least how many bits are needed to represent **-18** (read as minus 18) in **3**

i. Sign-magnitude system
ii. 1's complement system
iii. 2's complement system

Solution:

i. Sign-magnitude system

Formula = $-(2^{n-1} - 1) \rightarrow +(2^{n-1} - 1)$

⇨ At the least 6 bits are needed to represent -18.

	S	M
-18 =	1	10010

ii. 1's complement system

Formula = $-(2^{n-1} - 1) \rightarrow +(2^{n-1} - 1)$

⇨ At the least 6 bits are needed to represent -18.

+18 =	010010
-18 =	101101

iii. 2's complement system

Formula = $-(2^{n-1}) \rightarrow +(2^{n-1} - 1)$

⇨ At the least 6 bits are needed to represent -18.

+18 =	010010
-18 =	101110

Q. 3 In the following table fill the column B with an appropriate decimal number corresponding to the equivalent unsigned binary number given in column A. **2**

Column A	Column B
000	0
001	1
010	2
011	3
100	4
101	5
110	6
111	7

Solution:

Q. 4 In the following table fill the column B with an appropriate decimal number corresponding to the equivalent 1's complement number given in column A. **2**

Column A	Column B
000	+0
001	+1
010	+2
011	+3
100	-3
101	-2
110	-1
111	-0

<u>Solution:</u>

Q. 5 In the following table fill the column B with an appropriate decimal number corresponding to the equivalent 2's complement number given in column A. **2**

Column A	Column B
000	0
001	+1
010	+2
011	+3
100	-4
101	-3
110	-2
111	-1

<u>Solution:</u>

Q. 6 From the following truth table, directly write the Boolean expression for: **4**

i. F(A,B,C) in both the canonical forms.

ii. $\overline{\text{F(A,B,C)}}$ in both the canonical forms.

A	B	C	F
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

Solution:

i. F(A,B,C) in both the canonical forms.

$$F(A, B, C) = \sum_m(2, 3, 4, 6) \quad \text{(OR/sum of 1-minterms)}$$
$$= m_2 + m_3 + m_4 + m_6$$
$$= A'.B.C' + A'.B.C + A.B'.C' + A.B.C'$$

$$F(A, B, C) = \prod_M(0, 1, 5, 7) \quad \text{(AND/product of 0-maxterms)}$$
$$= M_0 \,.\, M_1 \,.\, M_5 \,.\, M_7$$
$$= (A+B+C) \,.\, (A+B+C') \,.\, (A'+B+C') \,.\, (A'+B'+C')$$

ii. $\overline{F(A,B,C)}$ in both the canonical forms.

$$\overline{F(A,B,C)} = \sum_m(0, 1, 5, 7) \quad \text{(OR/sum of 0-minterms)}$$
$$= m_0 + m_1 + m_5 + m_7$$
$$= A'.B'.C' + A'.B'.C + A.B'.C + A.B.C$$

$$\overline{F(A,B,C)} = \prod_M(2, 3, 4, 6) \quad \text{(AND/product of 1-maxterms)}$$
$$= M_2 \,.\, M_3 \,.\, M_4 \,.\, M_6$$
$$= (A+B'+C) \,.\, (A+B'+C') \,.\, (A'+B+C) \,.\, (A'+B'+C)$$

Q. 7 Write the truth table for the following Boolean expression/function: **2**

$$F(A,B,C) = \overline{B}.C + A.(\,\overline{B}+C\,) + \overline{A}.\overline{C}$$

A	B	C	F
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	1

Solution:

$$F(A, B, C) = B'.C + A.(B'+C) + A'.C'$$
$$=B'.C.(A'+A)+A.B'+A.C+A'.C'.(B'+B)$$
$$=A'.B'.C+A.B'.C+A.B'.(C'+C)+A.C.(B'+B)+A'.B'.C'+A'.B.C'$$
$$=A'.B'.C+A.B'.C+A.B'.C'+A.B'.C+A.B'.C+A.B.C+A'.B'.C'+A'.B.C'$$
$$=m_1+m_5+m_4+\cancel{m_5}+\cancel{m_5}+m_7+m_0+m_2$$
$$=m_0+m_1+m_2+m_4+m_5+m_7$$
$$=\sum_m(0, 1, 2, 4, 5, 7)$$

Q. 8 The following gates are available and the unit price is also listed. **4**

- Price of 3-input AND gate = \$ 2/-
- Price of 2-input OR gate = \$ 2/-
- Price of NOT gate = \$ 1/-

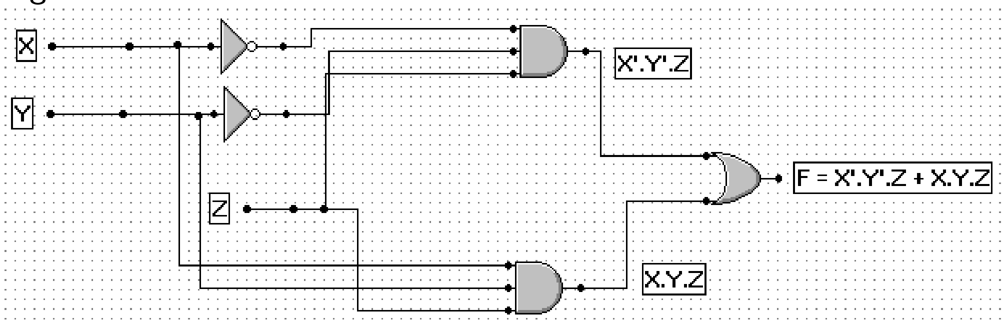
Implement the following Boolean function using the above gates. Draw its logic diagram and calculate its cost.

$$F(X,Y,Z) = \Sigma_m(1, 7)$$

Solution:

$$\begin{aligned} F(X,Y,Z) &= \Sigma_m(1, 7) \\ &= m_1 + m_7 \\ &= X'.Y'.Z + X.Y.Z \end{aligned}$$

Logic Circuit:

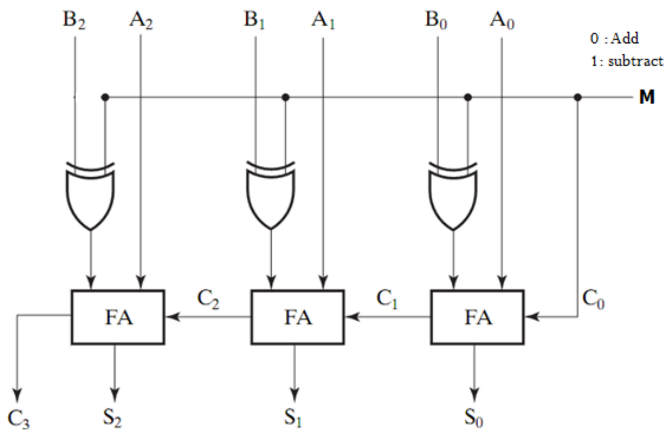


Cost Calculation:

Cost=2xNOT gates+2x3-input AND gates+1x2-input OR gate
=2x\$ 1+2x\$ 2+1x\$ 2
=\$ 2+\$ 4+\$ 2
=\$ 8

Q. 9 Design a 3-bit adder-subtractor circuit using 1-bit binary Full adders and any necessary additional logic gates. The circuit has a mode/control input bit, **M**, that controls its operation. Specifically, when **M=0**, the circuit becomes a 3-bit adder, and when **M=1**, the circuit becomes a 3-bit subtractor that performs the operation A plus the 2's complement of B, where Aand B are two 3-bits binary numbers. **5**

Solution:



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