

Fundamental Concepts

ONE MARK QUESTIONS

- 1.1 The logic function of a given 3-input majority gate is $M(a, b, c) = ab + bc + ca$.
But, the expected function has also 3 inputs as $M(M(a, b, c), M(a, b, \bar{c}), c)$

$$\therefore \text{say } Y = \overline{M(a, b, c)} \cdot M(a, b, \bar{c}) + M(a, b, \bar{c}) \cdot c + c \cdot \overline{M(a, b, c)}$$

$$\therefore Y = \overline{(ab + bc + ca)} \cdot (ab + b\bar{c} + \bar{c}a) + (ab + b\bar{c} + \bar{c}a) \cdot c + c \cdot \overline{(ab + bc + ca)}$$

Now applying De Morgan's theorem

$$\therefore Y = (\bar{a} + \bar{b})(\bar{b} + \bar{c})(\bar{c} + \bar{a}) \cdot (ab + b\bar{c} + \bar{c}a) + (ab + b\bar{c} + \bar{c}a) \cdot c + (\bar{a} + \bar{b})(\bar{b} + \bar{c})(\bar{c} + \bar{a}) \cdot c$$

$$\therefore Y = (\bar{a}\bar{b} + \bar{a}\bar{c} + \bar{b} + \bar{b}\bar{c})(\bar{c} + \bar{a}) \cdot (ab + b\bar{c} + \bar{c}a) + abc +$$

$$(\bar{a}\bar{b} + \bar{a}\bar{c} + \bar{b} + \bar{b}\bar{c})(\bar{c} + \bar{a}) \cdot c$$

$$\therefore Y = (\bar{b}(\bar{a} + 1) + \bar{a}\bar{c} + \bar{b}\bar{c})(\bar{a} + \bar{c}) \cdot (ab + b\bar{c} + \bar{c}a) + abc +$$

$$(\bar{b}(\bar{a} + 1) + \bar{a}\bar{c} + \bar{b}\bar{c})(\bar{a} + \bar{c}) \cdot c$$

$$\therefore Y = (\bar{b}(1 + \bar{c}) + \bar{a}\bar{c})(\bar{a} + \bar{c}) \cdot (ab + b\bar{c} + \bar{c}a) + abc + (\bar{b}(1 + \bar{c}) + \bar{a}\bar{c})(\bar{a} + \bar{c}) \cdot c$$

$$\therefore Y = (\bar{b} + \bar{a}\bar{c})(\bar{a} + \bar{c}) \cdot (ab + b\bar{c} + \bar{c}a) + abc + (\bar{b} + \bar{a}\bar{c})(\bar{a} + \bar{c}) \cdot c$$

$$\therefore Y = (\bar{a}\bar{b} + \bar{a}\bar{c} + \bar{b}\bar{c}) \cdot (ab + b\bar{c} + \bar{c}a) + abc + (\bar{a}\bar{b} + \bar{a}\bar{c} + \bar{b}\bar{c}) \cdot c$$

$$\therefore Y = (\bar{a}b\bar{c} + a\bar{b}\bar{c}) + abc + \bar{a}\bar{b}c$$

$$\therefore Y = f(a, b, c) = \Sigma(1, 2, 4, 7) \text{ which is a 3-input XOR gate i.e option 'd'.$$

- 1.2 $Y = \overline{\bar{C}((\bar{A} + \bar{B}) + C + AB)}$

But, it is given that $C = 0$.

$$\therefore Y = \overline{1 \cdot ((\bar{A} + \bar{B}) + 0 + AB)}$$

Now applying DeMorgan's theorem,

$$Y = \overline{(\bar{A} + \bar{B})} \cdot (\bar{A}B)$$

$$\therefore Y = (A + B)(\bar{A} + \bar{B})$$

$$\therefore Y = (A\bar{B} + \bar{A}B) \text{ i.e. option 'a'.$$

- 1.3 Obtaining expression for Y

$$\therefore Y = \overline{(PQ) \cdot (QR) \cdot (PR)}$$

$$\therefore Y = PQ + QR + PR$$

Therefore, two or more of the inputs must be 1 to obtain $Y = 1$ which is option 'b'.

- 1.4 When even number of 1's is present at the input XNOR gate, its output is 1. But inputs A and B are producing complementary outputs. Hence, C must be 1 so that $F = 1$ and there exist only one such option which is 'd'.

- 1.5 Obtaining expression for Y

$$\therefore Y = AB \oplus BC \oplus ABC$$

But, in an SOP expression all terms are mutually exclusive. So, XOR can be replaced with OR and logic expression can be simplified.

$$\therefore Y = AB(1 + C) + BC = B(A + C) \quad \text{i.e. option 'c'}$$

TWO MARK QUESTIONS

- 1.1 Note that input of G_2 is $\bar{C} \bar{D}$ and this term is ORed with G_1 input in the final expression. Therefore, G_2 must be an OR gate. This entails that the output of G_1 must be AND term but its inputs are bubbled. From DeMorgan's theorem, we know that NOR gate is equivalent to bubble input AND gate. So, G_1 must be a NOR gate which is option 'a'.

- 1.2 Let the output of XOR gate be = A, then the outputs of the AND gate is $F = (AZ + \bar{A}\bar{Z})A = AZ$. But we know that $A = X\bar{Y} + \bar{X}Y$. It means $\therefore F = X\bar{Y}Z + \bar{X}YZ$ i.e. option 'a'.

- 1.3 The output $Z = (\bar{P} + \bar{Q})(P + Q) = P\bar{Q} + \bar{P}Q$ which is an XOR function. Therefore, final output is $M_1 = (P \oplus Q) \oplus R$ and it is option 'd'.

- 1.4 If input to inverter is $P = 1$, its output is 0. Consequently, output of the subsequent NAND gate in the chain will be 1 as one of its inputs is low. This enables the next NAND gate in the chain whose other input is A. But, the last two NAND gates are forming an AND gate whose one input is at logic high level and the other input is A. Therefore, output $f = A$ which is option 'd'.

- 1.5 Truth Table of the given function is:

$$\text{Therefore, } f = \bar{x}\bar{y} + \bar{x}y + xy = \bar{x} + xy = \bar{x} + y.$$

To realize $\bar{x}$ one NOR gate is required and hence to implement this expression one NOR and one OR gate i.e. 2 units are required. Therefore, 'd' is the correct option.