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Internal Assessment Test 1 – September 2020

Sub:	Analog and Digital Electronics					Sub Code:	18CS33	Branch:	ISE
Date:	11.09.2020	Duration:	90 mins	Max Marks:	50	Sem/Sec:	3 – A, B, C		OBE

	Answer **any FIVE FULL** Questions	MARKS	CO	RBT
1	(a) Plot the following function on a Karnaugh map: F (A, B, C, D) = BD’ + B’CD + ABC + ABC’D + B’D’	2 M	CO3	L2
	(b) Find the minimum sum of products.	4 M	CO3	L3
	(c) Find the minimum product of sums.	4 M	CO3	L3
2	(a) Find the minimum SOP expression for the function below. Identify the essential prime implicants in your answer and substantiate with reasons, which minterm makes each one essential. F (a, b, c, d) = Π M (5, 7, 13, 14, 15) . Π D (1, 2, 3, 9)	5 M	CO3	L3
	(b) With the help of a flow chart, explain how to determine minimum sum of products using Karnaugh map. How do you identify PIs and EPIs in a given K-map?	5 M	CO3	L2
3	Assuming that inputs ABCD = 0101 and ABCD = 1011 never occur, find a simplified SOP and POS expression for the given function using K-maps: F = A’BC’D + A’B’D + A’CD + ABD + ABC	10 M	CO3	L3
4	For the given function, find any one minimum sum-of-products solution, using Quine Mc-Cluskey method: f(a, b, c, d) = ∑ m (1, 3, 4, 5, 6, 7, 10, 12, 13) + ∑ d (2, 9, 15)	10 M	CO3	L3
5	Find all the minimum solutions for the given function using Petrick’s method: F(a, b, c, d) = ∑ m (2, 4, 5, 6, 9, 10, 11, 12, 13, 15)	10 M	CO3	L3
6	Packages arrive at the stockroom and are delivered on carts to offices and laboratories by student employees. The carts and packages are various sizes and shapes. The students are paid according to the carts used. There are five carts and the pay for their use is Cart C1: $2	10 M	CO3	L4

	Cart C2: \$1 Cart C3: \$4 Cart C4: \$2 Cart C5: \$2 On a particular day, seven packages arrive, and they can be delivered using the five carts as follows: C1 can be used for packages P1, P3, and P4. C2 can be used for packages P2, P5, and P6. C3 can be used for packages P1, P2, P5, P6, and P7. C4 can be used for packages P3, P6, and P7. C5 can be used for packages P2 and P4. The stockroom manager wants the packages delivered at minimum cost. Using suitable minimization techniques, present a systematic procedure for finding the minimum cost solution.			
7	(a) What is Map-Entered Variable method? Explain using suitable example.	2 M	CO3	L2
	(b) Using MEV method, simplify the following function: f(A, B, C, D, E, F) = ∑ m (2, 3, 4, 5, 13, 15) + dc (8, 9 10, 11) + E (m0, m1) + F m7	8 M	CO3	L3
8	(a) Find the minimum SOP expression for the following function using MEV method: F (A, B, C, D, E, F, G) = ∑ m (0, 2, 8, 10) + E (m4, m6) + F (m9, m11) + G m3 + dc (1)	8 M	CO3	L3
	(b) Discuss the advantages of this method over other methods.	2 M	CO3	L2

Scheme Of Evaluation

Internal Assessment Test 1 – Sept.2020

Sub:	Analog and Digital Electronics							**Code:**	18CS33
Date:	11/09/2020	Duration:	90mins	Max Marks:	50	**Sem:**	III	**Branch:**	ISE

Note: Answer Any Five Questions

Question #	**Description**	**Marks Distribution**	**Max Marks**
1	a. Plot the following function on a Karnaugh map: F (A, B, C, D) = BD’ + B’CD + ABC + ABC’D + B’D’ • Plot the given terms on the K-map labelling the K-map coordinates correctly.	2 M	10 M
	b. Find the minimum sum of products. • Using K-Map for SOP form, calculate minimum SOP expression.	4 M	
	c. Find the minimum product of sums. • Using K-Map for POS form, calculate minimum POS expression.	4 M	
2	a. Find the minimum SOP expression for the function below. Identify the essential prime implicants in your answer and substantiate with reasons, which minterm makes each one essential. F (a, b, c, d) = Π M (5, 7, 13, 14, 15) . Π D (1, 2, 3, 9) • Plot the given function in K-Map • Find the minimum SOP solution from the K-map • Identify the prime implicants • Identify and list out the EPIs mentioning which minterm makes each one essential.	5M	10 M
	b. With the help of a flow chart, explain how to determine minimum sum of products using Karnaugh map. How do you identify PIs and EPIs in a given K-map?	5M	

	• Flowchart to get the minimum SOP from a K-map • Define a PI and EPI and how to locate them on a K-map		
3	Assuming that inputs ABCD = 0101 and ABCD = 1011 never occur, find a simplified SOP and POS expression for the given function using K-maps: F = A'BC'D + A'B'D + A'CD + ABD + ABC • The inputs which are mentioned as do not occur must be marked as don't cares in the K-map • Using a K-map, get the minimum SOP expression • Using a separate K-map, get the minimum POS expression	10 M	10 M

4	For the given function, find any one minimum sum-of-products solution, using Quine Mc-Cluskey method:
	f(a, b, c, d) = Σ m (1, 3, 4, 5, 6, 7, 10, 12, 13) + Σ d (2, 9, 15)
	• Follow the steps as per QM method:
	  ○ List the binary form of given minterms and don't cares
	  ○ Categorize them into groups based on their index
	  ○ Compare and combine terms with only one bit difference from among adjacent groups
	  ○ Continue the previous step until no more terms can be combined
	  ○ Identify the PIs and list them out in the PI chart
	  ○ Draw the PI chart with PIs as rows and only minterms given in the function as columns
		10 M	10 M

	○ Mark the minterms covered by each PI ○ Identify the EPI ○ Find minimum solution for remaining uncovered minterms if any by trial and error method		
5	Find all the minimum solutions for the given function using Petrick's method: F(a, b, c, d) = Σ m (2, 4, 5, 6, 9, 10, 11, 12, 13, 15) • Follow the QM method up to getting the PI chart • Identify the EPIs if any. Ignore the EPIs and minterms covered by the EPIs • Label all PI rows except the one with the EPI as P1, P2… and identify the remaining uncovered minterms • Find a logical function P in terms of P1, P2… that is true when all the above said uncovered minterms are covered. • Simply P using the laws (X+Y)(X+Z) = X+YZ and X+XY=X • Identify all possible solutions for the given function and all minimum solutions from this.	5 M + 5 M	10 M
6	Packages arrive at the stockroom and are delivered on carts to offices and laboratories by student employees. The carts and packages are various sizes and shapes. The students are paid according to the carts used. There are five carts and the pay for their use is Cart C1: $2 Cart C2: $1	10 M	10 M

	Cart C3: \$4 Cart C4: \$2 Cart C5: \$2 On a particular day, seven packages arrive, and they can be delivered using the five carts as follows: C1 can be used for packages P1, P3, and P4. C2 can be used for packages P2, P5, and P6. C3 can be used for packages P1, P2, P5, P6, and P7. C4 can be used for packages P3, P6, and P7. C5 can be used for packages P2 and P4. The stockroom manager wants the packages delivered at minimum cost. Using suitable minimization techniques, present a systematic procedure for finding the minimum cost solution. • Use the Petrick's method to determine the minimum cost solution • Steps are detailed in the previous question's answer.		
7	a. What is Map-Entered Variable method? Explain using suitable example. • Explain the method • Give a simple example to explain this method	2 M	10 M
	b. Using MEV method, simplify the following function: f(A, B, C, D, E, F) = Σ m (2, 3, 4, 5, 13, 15) + dc (8, 9 10, 11) + E (m0, m1) + F m7 • Plot the given function on a 4 variable K-map • Find MS0, MS1 and MS2. • Find the final minimum solution combining the solutions obtained in the previous step	8 M	

<table>
<tr><td rowspan="2">8</td><td>a. Find the minimum SOP expression for the following function using MEV method: F (A, B, C, D, E, F, G) = Σ m (0, 2, 8, 10) + E (m4, m6) + F (m9, m11) + G m3 + dc (1)
• Plot the given function on a 4 variable K-map
• Find MS0, MS1, MS2 and MS3.
• Find the final minimum solution combining the solutions obtained in the previous step</td><td>8 M</td><td rowspan="2">10 M</td></tr>
<tr><td>b. Discuss the advantages of this method over other methods
• State the advantages of MEV method over using K-map or QM method in terms of complexity, time etc.</td><td>2 M</td></tr>
</table>

1.(a) Plot the following fn on a K-map.

$F(A,B,C,D) = B\bar{D} + \bar{B}CD + ABC + AB\bar{C}D + \bar{B}\bar{D}$

(b) Find the minimum SOP

(c) Find the minimum POS.

Answer :

$F(A,B,C,D) = B\bar{D} + \bar{B}CD + ABC + AB\bar{C}D + \bar{B}\bar{D}$

(a).

AB \ CD	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	1	0	1	1
$\bar{A}B$	1	0	0	1
AB	1	1	1	1
$A\bar{B}$	1	0	1	1

(b)

AB \ CD	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	1	0	1	1
$\bar{A}B$	1	0	0	1
AB	1	1	1	1
$A\bar{B}$	1	0	1	1

Minimum SOP.

$F = \bar{D} + AB + \bar{B}C$

(c)

AB \ CD	$C+D$	$C+\bar{D}$	$\bar{C}+\bar{D}$	$\bar{C}+D$
$A+B$	1	0	1	1
$A+\bar{B}$	1	0	0	1
$\bar{A}+\bar{B}$	1	1	1	1
$\bar{A}+B$	1	0	1	1

Minimum POS.

$F = (A+\bar{B}+\bar{D}) \cdot (B+C+\bar{D})$

2 (a) Find the minimum SOP expression for each function. Underline the EPI and tell which minterms makes each one essential. $F(a,b,c,d) = \Pi M(5,7,13,14,15) \cdot \Pi D(1,2,3,9)$

~~(a) f(a,b,c,d) = Σm(0, 1, 3, 5, 6, 7, 14, 12, 14)~~

ab \ cd	$\bar{c}\bar{d}$	$\bar{c}d$	cd	$c\bar{d}$
$\bar{a}\bar{b}$	1 (0)	X (1)	X (3)	X (2)
$\bar{a}b$	1 (4)	0 (5)	0 (7)	1 (6)
ab	1 (12)	0 (13)	0 (15)	0 (14)
$a\bar{b}$	1 (8)	X (9)	1 (11)	1 (10)

Minimum SOP

$$f = \bar{b} + \bar{c}\bar{d} + \bar{a}\bar{d}$$

PIs :- $\bar{b}$, $\bar{c}\bar{d}$, $\bar{a}\bar{d}$, $\bar{b}\bar{d}$

~~EPIs~~:-

Essential Prime Implicants :-

$\bar{b}$ is an EPI due to minterms 11

$\bar{c}\bar{d}$ is an EPI due to minterm 12

$\bar{a}\bar{d}$ is an EPI due to minterm 6.

3. Assuming that i/ps ABCD = 0101 and ABCD = 1011 never occur, find a simplified SOP + POS expression for the given fn using K-maps:

$$F = \bar{A}B\bar{C}D + \bar{A}\bar{B}D + \bar{A}CD + ABD + ABC.$$

AB \ CD	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$		1	1	
$\bar{A}B$		X	1	
AB		1	1	1
$A\bar{B}$			X	

Minimum SOP :-

① $\cancel{F = \bar{A}D + ABD + ABC}$

② $\cancel{F = BD + ABC +}$

AB \ CD	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$		1	1	
$\bar{A}B$		X	1	
AB		1	1	1
$A\bar{B}$			X	

Minimum SOP:

$$F = \bar{A}D + BD + ABC.$$

AB \ CD	$C+D$	$C+\bar{D}$	$\bar{C}+\bar{D}$	$\bar{C}+D$
$A+B$	0			0
$A+\bar{B}$	0	X		0
$\bar{A}+\bar{B}$	0			
$\bar{A}+B$	0	0	X	0

Minimum POS :-

$$F = (A+D)(\bar{A}+B)(C+D)$$

4. QM method:

$f(a,b,c,d) = \Sigma m(1,3,4,5,6,7,10,12,13) + \Sigma d(2,9,15)$

Column 0

1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
9	1001
10	1010
12	1100
13	1101
15	1111

Column 1

Index 1:	1	0001
	2	0010
	4	0100
Index 2:	3	0011
	5	0101
	6	0110
	9	1001
	10	1010
	12	1100
Index 3:	7	0111
	13	1101
Index 4:	15	1111

Column 2

(1,3)	00–1	
(1,5)	0–01	
(1,9)	–001	
(2,3)	001–	
(2,6)	0–10	
(2,10)	–010	7
(4,5)	010–	
(4,6)	01–0	
(4,12)	–100	
(3,7)	0–11	
(5,7)	01–1	
(5,13)	–101	
(6,7)	011–	
(9,13)	1–01	
(12,13)	110–	
(7,15)	–111	
(13,15)	11–1	

Column 3

(1,3,5,7)	0– –1	1
(1,5,3,7)	0– –1	
(1,5,9,13)	– –01	2
(1,9,5,13)	– –01	
(2,3,6,7)	0–1–	3
(2,6,3,7)	0–1–	
(4,5,6,7)	01– –	4
(4,5,12,13)	–10–	5
(4,6,5,7)	01– –	4
(4,12,5,13)	–10–	5
(5,7,13,15)	–1–1	6
(5,13,7,15)	–1–1	

PI chart

PIs	m_1	m_3	m_4	m_5	m_6	m_7	m_{10}	m_{12}	m_{13}
$\bar{B}C\bar{D}$ (2,10)							X		
$\bar{A}D$ (1,3,5,7)	X	X		X		X			
$\bar{C}D$ (1,5,9,13)	X			X					X
$\bar{A}C$ (2,3,6,7)		X			X	X			
$\bar{A}B$ (4,5,6,7)			X	X	X	X			
$B\bar{C}$ (4,5,12,13)			X	X				X	X
BD (5,7,13,15)				X		X			X

EPIs:→ $\bar{B}C\bar{D}$ & $B\bar{C}$; Remaining minterms to be covered are 1, 3, 6 & 7

∴ Minimum solution is :

$$F = \bar{B}C\bar{D} + B\bar{C} + \underbrace{\bar{A}D}_{\text{(covers } m_1, m_3 \,\&\, m_7)} + \bar{A}C \text{ (covers } m_6) \text{ (or } \bar{A}B)$$

5. Petrick's method

$f(a,b,c,d) = \Sigma m\,(2,4,5,6,9,10,11,12,13,15)$.

Column 0		Column 1			Column 2		
2	0010 ✓	Index 1:	2	0010 ✓	(2,6)	0-10	①
4	0100 ✓		4	0100 ✓	(2,10)	-010	②
5	0101 ✓	Index 2:	5	0101 ✓	(4,5)	010- ✓	
6	0110 ✓		6	0110 ✓	(4,6)	01-0	③
9	1001 ✓		9	1001 ✓	(4,12)	-100 ✓	
10	1010 ✓		10	1010 ✓			
11	1011 ✓		12	1100 ✓	(5,13)	-101 ✓	
12	1100 ✓	Index 3:	11	1011 ✓	(9,11)	10-1 ✓	
13	1101 ✓		13	1101 ✓	(9,13)	1-01 ✓	
15	1111 ✓	Index 4	15	1111 ✓	(10,11)	101-	④
					(12,13)	110- ✓	
					(11,15)	1-11 ✓	
					(13,15)	11-1 ✓	

Column 3

(4,5,12,13)	-10-	⑤
(4,12,5,13)	-10-	⑤
(9,11,13,15)	1--1	⑥
(9,13,11,15)	1--1	⑥

PIs

(2,6)	0-10	$\bar{A}C\bar{D}$
(2,10)	-010	$\bar{B}C\bar{D}$
(4,6)	01-0	$\bar{A}B\bar{D}$
(10,11)	101-	$A\bar{B}C$
(4,5,12,13)	-10-	$B\bar{C}$
(9,11,13,15)	1--1	AD

PI chart :-

	PIs.	m_2	m_4 ✓	m_5 ✓	m_6	m_9 ✓	m_{10}	m_{11} ✓	m_{12} ✓	m_{13} ✓	m_{15} ✓
P_1	$\bar{A}C\bar{D}$ (2,6)	X			X						
P_2	$\bar{B}C\bar{D}$ (2,10)	X					X				
P_3	$\bar{A}B\bar{D}$ (4,6)		X		X						
P_4	$A\bar{B}C$ (10,11)						X	X			
EPI ✓	$B\bar{C}$ (4,5,12,13)		X	X					X	X	
EPI ✓	AD (9,11,13,15)					X		X		X	X

EPIs :- $B\bar{C}$, AD .

Remaining minterms to be covered are m_2, m_6 & m_{10} .

$m_2 \rightarrow (P_1 + P_2)$; $m_6 \rightarrow (P_1 + P_3)$; $m_{10} \rightarrow (P_2 + P_4)$

$$\therefore P = (P_1 + P_2)(P_1 + P_3)(P_2 + P_4)$$
$$= (P_1 + P_2 P_3)(P_2 + P_4)$$
$$= \underset{①}{P_1 P_2} + \underset{②}{P_1 P_4} + \underset{③}{P_2 P_3} + \underset{④}{P_2 P_3 P_4}$$

$$\left[\begin{array}{l}(X+Y)(X+Z) = X + YZ \\ X + XY = X\end{array}\right.$$

4 possible solutions ; 3 minimum solutions ①, ② & ③ .

① $\rightarrow P_1 P_2 \rightarrow \bar{A}C\bar{D} + \bar{B}C\bar{D}$

② $\rightarrow P_1 P_4 \rightarrow \bar{A}C\bar{D} + A\bar{B}C$

③ $\rightarrow P_2 P_3 \rightarrow \bar{B}C\bar{D} + \bar{A}B\bar{D}$

Minimum solutions are :

① $\bar{A}C\bar{D} + \bar{B}C\bar{D} + B.\bar{C} + AD$

② $\bar{A}C\bar{D} + A\bar{B}C + B\bar{C} + AD$

③ $\bar{B}C\bar{D} + \bar{A}B\bar{D} + B\bar{C} + AD$

7. a) MEV Method :

→ Modified form of K-map method.
→ Used when we have large no. of i/p variables and lesser minterms in the function that needs to be simplified.
→ Can be used to simplify ~~K-maps~~ such functions using a K-map of lower order, like a 4 variable K-map.
→ This is done by writing the output in terms of the input variables.

b) $f(A,B,C,D,E,F) = \Sigma m(2,3,4,5,13,15) + dc(8,9,10,11) + E(m_0, m_1) + F \cdot m_7$.

AB \ CD	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	E (0)	E (1)	1 (3)	1 (2)
$\bar{A}B$	1 (4)	1 (5)	F (7)	(6)
AB	(12)	1 (13)	1 (15)	(14)
$A\bar{B}$	X (8)	X (9)	X (11)	X (10)

① MS_0 :- E = 0, F = 0

AB \ CD	00	01	11	10
00	0	0	1	1
01	1	1	0	
11		1	1	
10	X	X	X	X

$MS_0 = \bar{B}C + AD + \bar{A}B\bar{C}$

② MS_1 :- E = 1, F = 0, 1s → X

AB \ CD	00	01	11	10
00	1	1	X	X
01	X	X	0	
11		X	X	
10	X	X	X	X

$MS_1 = \bar{B}$

③ MS_2 :- E = 0, F = 1, 1s → X

AB \ CD	00	01	11	10
00	0	0	X	X
01	X	X	1	
11		X	X	
10	X	X	X	X

$MS_2 = CD$ or BD

Minimum solution is:

$$f = MS_0 + E \cdot MS_1 + F \cdot MS_2$$

$$\therefore \; = \overline{B}C + \overline{A}D + \overline{A}B\overline{C} + \overline{B}E + (CDF \text{ or } BDF).$$

8. a) $F(A,B,C,D,E,F,G) = \Sigma m(0,2,8,10) + E(m_4, m_6) + F(m_9, m_{11}) + G m_3 + d.c(1)$.

AB \ CD	00	01	11	10
00	1_0	X_1	G_3	1_2
01	E_4	$_5$	$_7$	E_6
11	$_{12}$	$_{13}$	$_{15}$	$_{14}$
10	1_8	F_9	F_{11}	1_{10}

① MS_0 :- $E = 0$, $F = 0$, $G = 0$

AB \ CD	00	01	11	10
00	1	X	0	1
01	0			0
11				
10	1	0	0	1

$MS_0 = \overline{B}\,\overline{D}$

② MS_1 :- $E = 1$, $F = G = 0$, 1s → X

AB \ CD	00	01	11	10
00	X	X	0	X
01	1			1
11				
10	X	0	0	X

$MS_1 = \overline{A}\,\overline{D}$

③ MS_2 :- $F = 1$, $E = G = 0$, 1s → X

AB \ CD	00	01	11	10
00	X	X	0	X
01	0			0
11				
10	X	1	1	X

$MS_2 = A\overline{B}$

④ MS_3 :- $G = 1$, $E = F = 0$, 1s → X

AB \ CD	00	01	11	10
00	X	X	1	X
01	0			0
11				
10	X	0	0	X

$MS_3 = \overline{A}\,\overline{B}$

$\therefore$ Minimum soln: is $F = MS_0 + E \cdot MS_1 + F \cdot MS_2 + G \cdot MS_3$

$$= \overline{B}\,\overline{D} + \overline{A}\,\overline{D}E + A\overline{B}F + \overline{A}\,\overline{B}G$$

8b) → It is used when we have large no: of i/p variables and lesser minterms in the function to be simplified.

→ It uses a K-map of lower order to do the simplification

→ This is done by expressing the o/p function in terms of the i/p variables.

ie, it can be used to plot more than 'n' variables using an 'n-variable' K-map.

→ Commonly used to solve problems involving multiplexers.

→ For normal K-maps with ~~large~~ no: of i/p variables (say n), size of K-map will be 2^n cells. This becomes difficult to simplify when no: of i/p variables exceeds 4. This can be avoided in the MEV method.

→ The QM method can be used to overcome the cons of K-map method, but it is a very lengthy process and takes a lot of time for completion.

→ MEV method obtains the simplified/minimum solutions in very less time.

$\boxed{619}$ Defects

	P_1	P_2	P_3	P_4	P_5	P_6	P_7	
C_1	x		x	x				$\rightarrow S_1$
C_2		x			x	x		$\rightarrow S_2$
C_3	x	x			x	x	x	$\rightarrow S_3$
C_4			x			x	x	$\rightarrow S_4$
C_5		x		x				$\rightarrow S_5$

$$C = (C_1 + C_3)(C_2 + C_3 + C_5)(C_1 + C_4)(C_1 + C_5)(C_2 + C_3) \cdot (C_2 + C_3 + C_4)(C_3 + C_4).$$

$$= (C_1 + C_3C_4)(C_2 + C_3 + C_4C_5)(C_3 + C_2C_4)(C_1 + C_5)$$

$$= (C_1C_2 + C_1C_3 + C_1C_4C_5 + C_2C_3C_4 + C_3C_4 + C_3C_4C_5)(C_1C_3 + C_3C_5 + C_1C_2C_4 + C_2C_4C_5).$$

$$= C_1C_2C_3 + C_1C_2C_3C_5 + C_1C_2C_4 + C_1C_2C_4C_5 +$$
$$C_1C_3 + C_1C_3C_5 + \cancel{C_1C_2C_3C_5} + C_1C_2C_3C_4C_5 +$$
$$C_1C_3C_4C_5 + \cancel{C_1C_3C_4C_5} + \cancel{C_1C_2C_4C_5} + \cancel{C_1C_2C_4C_5} +$$
$$C_1C_2C_3C_4 + C_2C_3C_4C_5 + \cancel{C_1C_2C_3C_4} + \cancel{C_2C_3C_4C_5} +$$
$$C_1C_3C_4 + C_3C_4C_5 + \cancel{C_1C_2C_3C_4C_5} + \cancel{C_2C_3C_4C_5} +$$
$$\cancel{C_1C_3C_4C_5} + \cancel{C_3C_4C_5} + \cancel{C_1C_2C_3C_4C_5} + \cancel{C_2C_3C_4C_5}$$

$$= C_1C_2C_3 + C_1C_2C_3C_5 + C_1C_2C_4 + C_1C_2C_4C_5 +$$
$$C_1C_3 + C_1C_3C_5 + C_1C_2C_3C_4C_5 + C_1C_3C_4C_5 +$$
$$C_1C_2C_3C_4 + C_2C_3C_4C_5 + C_1C_3C_4 + C_3C_4C_5.$$

$$= C_1C_2C_3 + C_1C_2C_4 + C_1C_3 + C_1C_3C_4C_5 + C_1C_3C_4 + C_3C_4C_5$$

$$= C_1C_3 + C_1C_2C_4 + C_1C_3C_4 + C_3C_4C_5$$

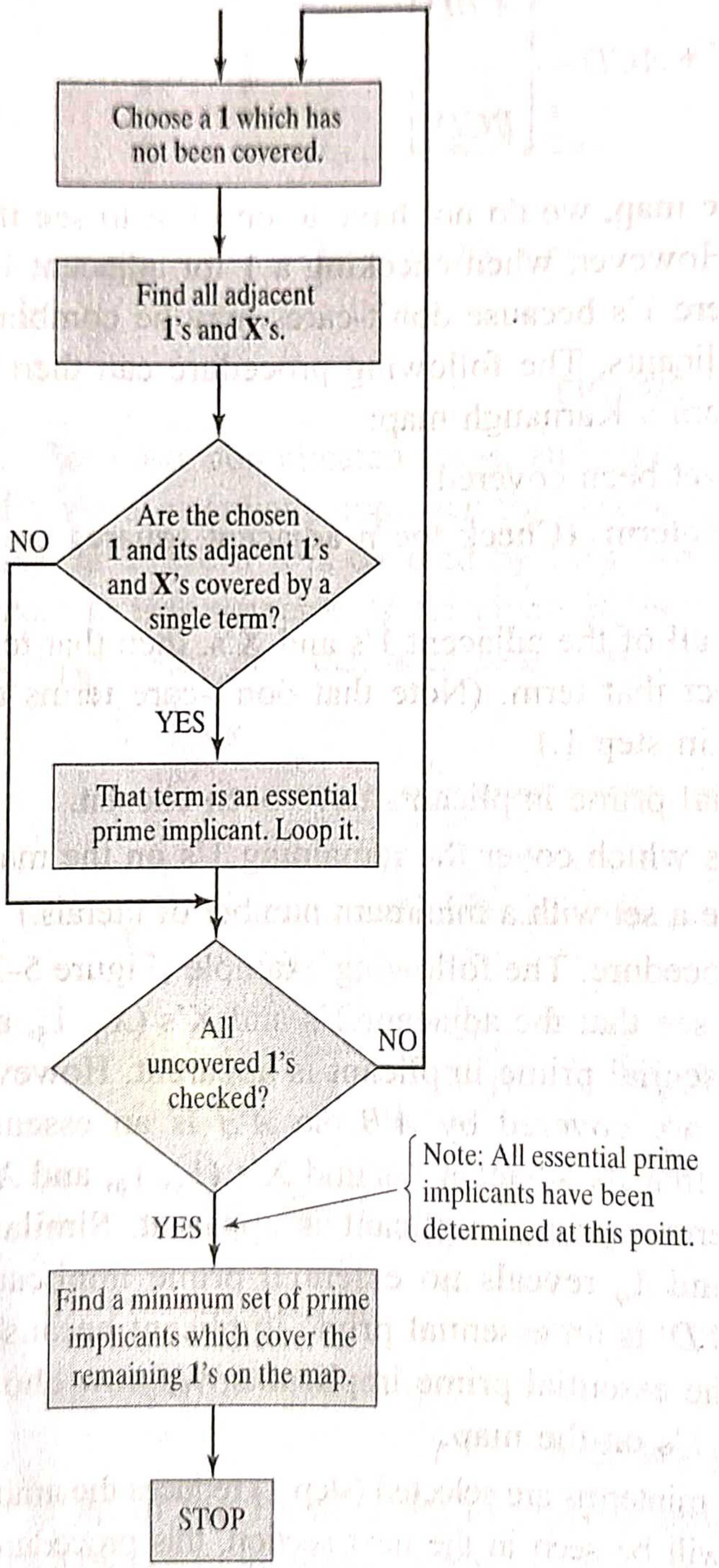
$$= \underset{(1)}{C_1C_3} + \underset{(2)}{C_1C_2C_4} + \underset{(3)}{C_3C_4C_5}$$

$\Rightarrow$ 3 possible costs, out of which 1 is minimum
ie, C_1C_3 combination

$\therefore$ The minimum cost solution is $C_1 + C_3$

ie, A combination of C_1 (\$2) and C_3 (\$4) will ensure minimum cost as well as get all packets delivered.

2b.



Prime Implicants – Any implicant group that cannot be combined with another similar implicant group to form a larger group is a Prime implicant. If a pair is not part of a quad or if a quad is not part of an octet, or if an octet cannot be combined with another octet, then the pair, quad and octet respectively are PIs.

Essential Prime Implicants – If there is any minterm that is covered by only one PI group, then that PI is an essential PI.