2.17 (b) Find the truth table

$$y = \underbrace{(cd + b'c + bd')}(b+d)$$

b	c	d	cd	b'c	bd'		b+d	Y
0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	1	0
0	1	0	0	1	0	1	0	0
0	1	1	1	1	0	1	1	1
1	0	0	0	0	1	1	1	1
1	0	1	0	0	0	0	1	0
1	1	0	0	0	1	1	1	1
1	1	1	1	0	0	1	1	1

AND

2.30 Write the following in sum-of-products form

$$F = (b+d)(a' + b' + c)$$
$$= ba' + \cancel{bb'} + bc + da' + db' + dc$$

What are the minterms of F?

a	b	c	d	ba'	bc	da'	db'	dc	F
0	0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	1	1	0	1
0	0	1	0	0	0	0	0	0	0
0	0	1	1	0	0	1	1	1	1
0	1	0	0	1	0	0	0	0	1
0	1	0	1	1	0	1	0	0	1
0	1	1	0	1	1	0	0	0	1
0	1	1	1	1	1	1	0	1	1
1	0	0	0	0	0	0	0	0	0
1	0	0	1	0	0	0	1	0	1
1	0	1	0	0	0	0	0	0	0
1	0	1	1	0	0	0	1	1	1
1	1	0	0	0	0	0	0	0	0
1	1	0	1	0	0	0	0	0	0
1	1	1	0	0	1	0	0	0	1
1	1	1	1	0	1	0	0	1	1

$$F = \Sigma(1,3,4,5,6,7,9,11,14,15)$$
$$= m_1 + m_3 + m_4 + m_5 + m_6 + m_7$$
$$+ m_9 + m_{11} + m_{14} + m_{15}$$

$$= a'b'c'd + a'b'cd + a'bc'd' + a'bc'd + a'bcd'$$
$$+ a'bcd + ab'c'd + ab'cd + abcd'$$
$$+ abcd$$

2.31 Write in product-of-sums form

$$F = a'b + a'c' + abc$$

a b c	a'b	a'c'	abc	F
0 0 0	0	1	0	1
0 0 1	0	0	0	0
0 1 0	1	1	0	1
0 1 1	1	0	0	1
1 0 0	0	0	0	0
1 0 1	0	0	0	0
1 1 0	0	0	0	0
1 1 1	0	0	1	1

$$F = \Pi(1, 4, 5, 6)$$
$$= M_1 M_4 M_5 M_6$$

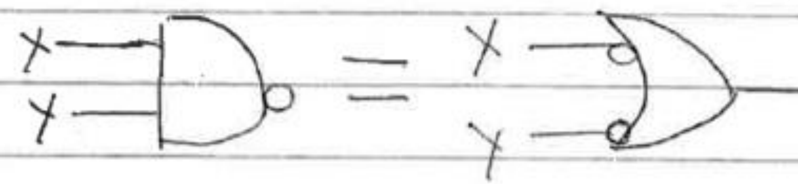
$$F = \underbrace{(a+b+c')}_{M_1} \underbrace{(a'+b+c)}_{M_4} \underbrace{(a'+b+c')}_{M_5} \underbrace{(a'+b'+c)}_{M_6}$$

2.4 - 2.5 DeMorgan's Theorem

$$\overline{XY} = \overline{X} + \overline{Y}$$

change operator
complement variables

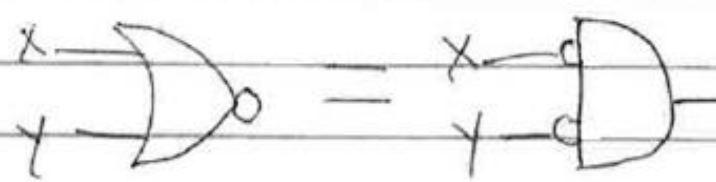
X	Y	$\overline{XY}$	$\overline{X}+\overline{Y}$
0	0	1	1
0	1	1	1
1	0	1	1
1	1	0	0



$$\overline{X+Y} = \overline{X}\ \overline{Y}$$

change operator
complement variables

X	Y	$\overline{X+Y}$	$\overline{X}\cdot\overline{Y}$
0	0	1	1
0	1	0	0
1	0	0	0
1	1	0	0



2.4 - 2.5 DeMorgan's Theorem

- Simplify $C + \overline{BC}$

$$C + \overline{BC}$$

$$C + (\overline{B} + \overline{C})$$

$$(C + \overline{C}) + \overline{B}$$

$$1 + \overline{B}$$

$$1$$

2.4 - 2.5 DeMorgan's Theorem

Simplify $\overline{AB}(\overline{A} + B)$

$$\overline{AB}(\overline{A} + B)$$

$$(\overline{A} + \overline{B})(\overline{A} + B)$$

$$\overline{A} + \overline{A}B + \overline{A}\overline{B}$$

$$\overline{A}$$

2.4 - 2.5 DeMorgan's Theorem

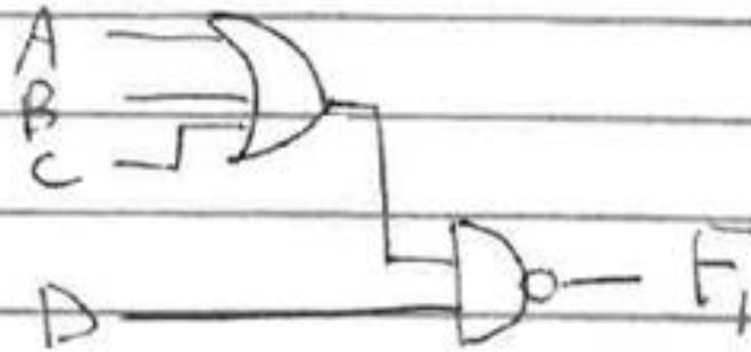
$$\overline{ABCD} = \bar{A} + \bar{B} + \bar{C} + \bar{D}$$

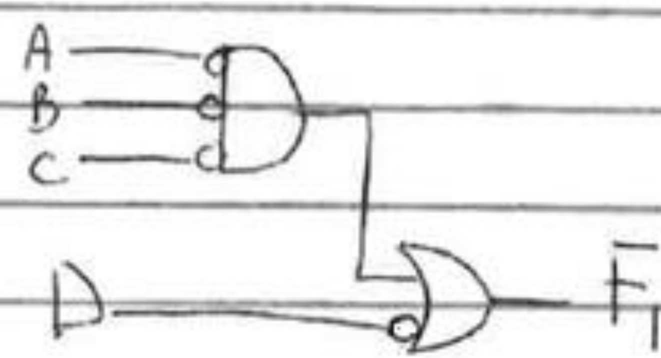
$$\overline{A+B+C+D} = \bar{A}\,\bar{B}\,\bar{C}\,\bar{D}$$

$$F_1 = \overline{(A+B+C)D}$$

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

$$= \bar{A}\,\bar{B}\,\bar{C} + \bar{D}$$





Change only one type of operator at a time, then "split" the complement bar

2.4 - 2.5 DeMorgan's Theorem

$$F_2 = \overline{ABC + DEF}$$

$$= \overline{ABC} \cdot \overline{DEF}$$

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

$$F_3 = \overline{A\bar{B} + \bar{C}D + EF}$$

$$= (\overline{A\bar{B}}) \cdot (\overline{\bar{C}D})(\overline{EF})$$

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

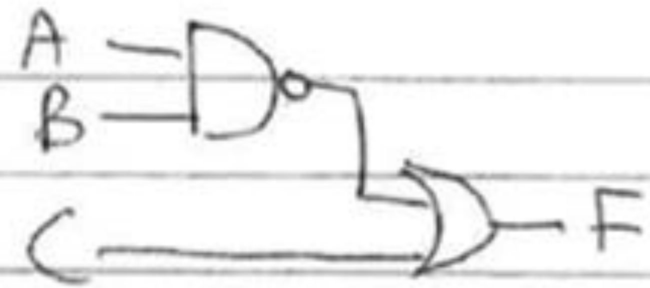
$$= (\bar{A} + B)(C + \bar{D})(\bar{E} + \bar{F})$$

Change only one type of operator at a time, then "split" the complement bar

2.4 - 2.5 DeMorgan’s Theorem

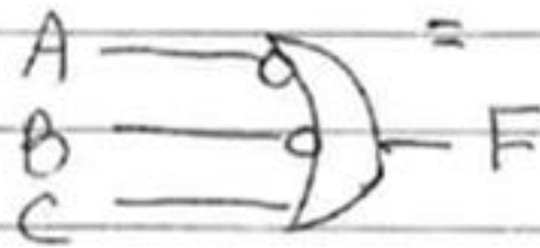
not in Standard form

$F = \overline{AB} + C$



SOP form $= \bar{A} + \bar{B} + C$

=



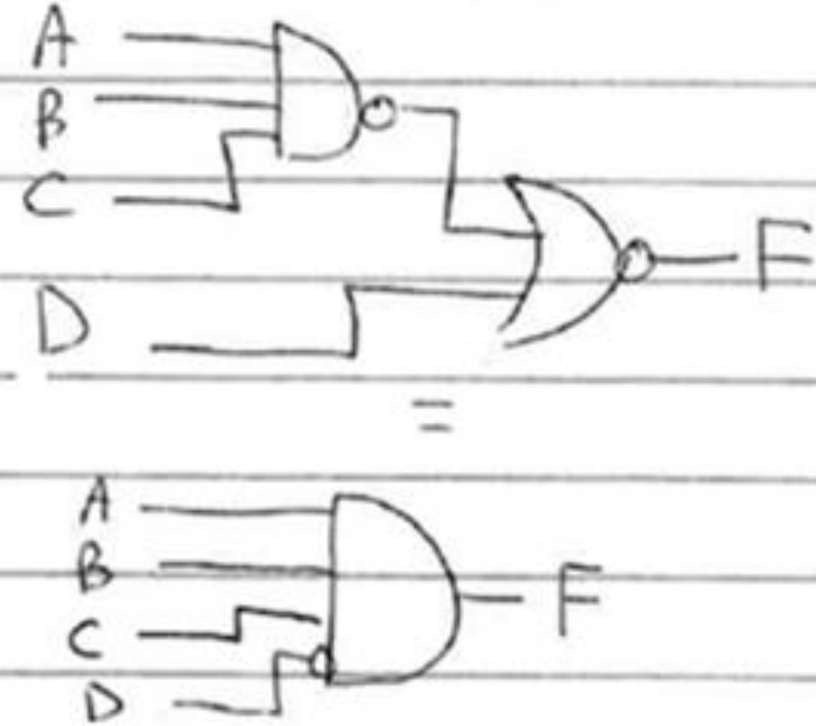
2.4 - 2.5 DeMorgan’s Theorem

$$F = \overline{\overline{(ABC)} + D}$$

$$= \overline{\overline{(ABC)}} \cdot \overline{D}$$

$$= (ABC) \cdot \overline{D}$$

$$= ABC\overline{D}$$



2.4 - 2.5 DeMorgan's Theorem

$$F_1 = \overline{(\overline{X \cdot \overline{Y}}) \cdot (\overline{Y} + Z)}$$

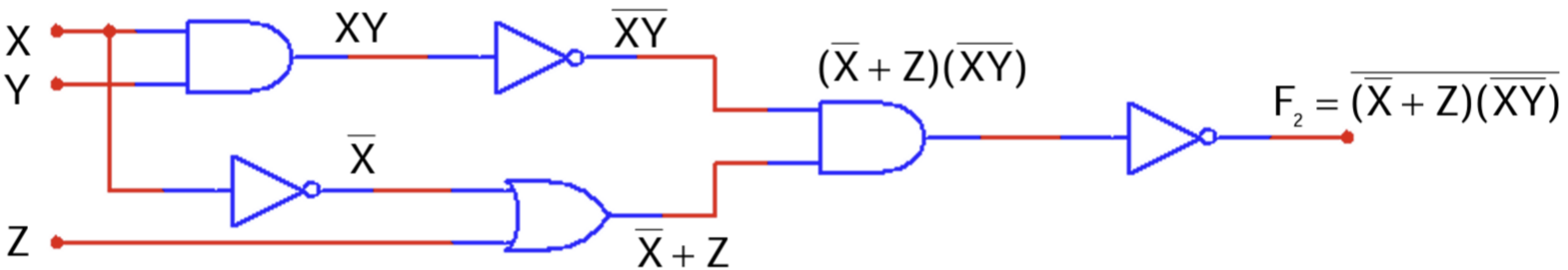
$$F_1 = (\overline{\overline{X \cdot \overline{Y}}}) + (\overline{\overline{Y} + Z})$$

$$F_1 = (X \cdot \overline{Y}) + (\overline{\overline{Y}} \cdot \overline{Z})$$

$$F_1 = (X \cdot \overline{Y}) + (Y \cdot \overline{Z})$$

$$\boxed{F_1 = X\overline{Y} + Y\overline{Z}}$$

2.4 - 2.5 DeMorgan's Theorem



2.4 - 2.5 DeMorgan's Theorem

$$F_2 = \overline{(\overline{X} + Z)(\overline{XY})}$$

$$F_2 = (\overline{\overline{X} + Z}) + (\overline{\overline{XY}})$$

$$F_2 = (\overline{\overline{X} + Z}) + (XY)$$

$$F_2 = (\overline{\overline{X}}\,\overline{Z}) + (XY)$$

$$F_2 = (X\,\overline{Z}) + (XY)$$

$$F_2 = X\,\overline{Z} + X\,Y$$

2.4 - 2.5 DeMorgan's Theorem

Prob 2.24

$$F = \overline{(A \oplus B)}$$

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

$$= (\overline{A\bar{B}})(\overline{\bar{A}B})$$

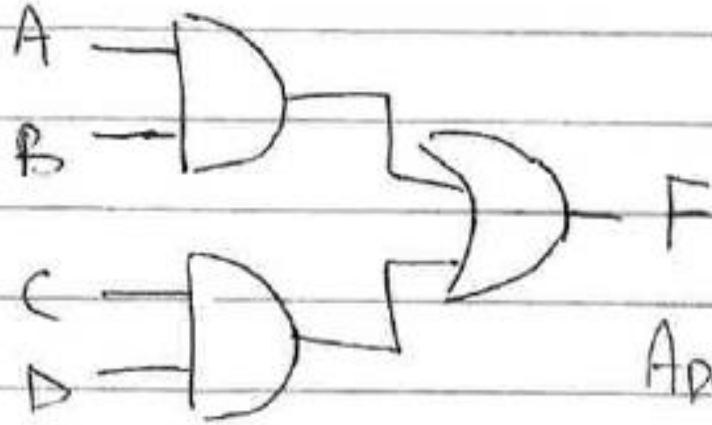
$$= (\bar{A} + \bar{\bar{B}})(\bar{\bar{A}} + \bar{B})$$

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

$$= \cancel{\bar{A}A} + \bar{A}\bar{B} + BA + \cancel{B\bar{B}}$$

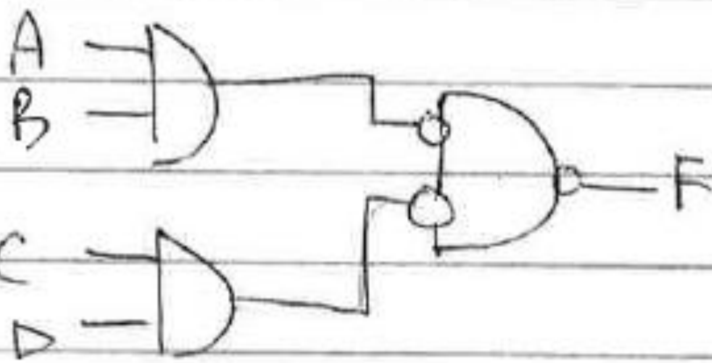
$$= \bar{A}\bar{B} + AB = A \odot B$$

2.4 - 2.5 DeMorgan's Theorem

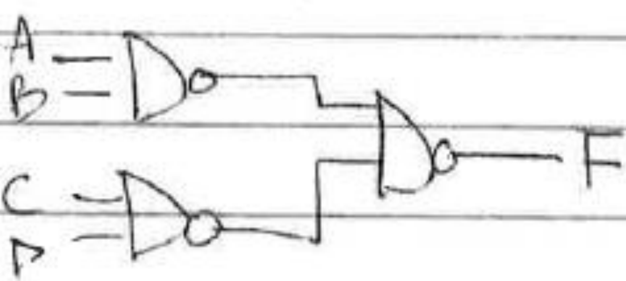


AND/OR

Apply De Morgan's graphically

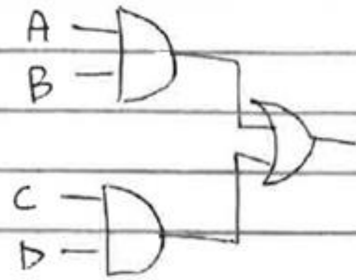


(change operators
complement variables)



NAND/NAND

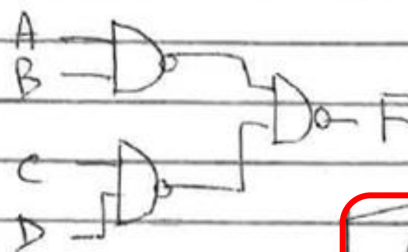
2.4 - 2.5 DeMorgan's Theorem



$F = AB + CD$ SOP form

$F = \overline{\overline{F}} = \overline{\overline{AB+CD}}$

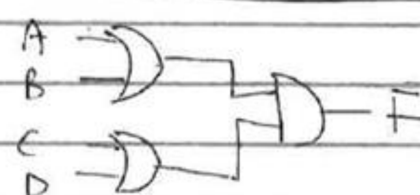
$= \overline{(\overline{AB})(\overline{CD})}$



these two structures are the same

AND/OR structure = NAND/NAND Structure

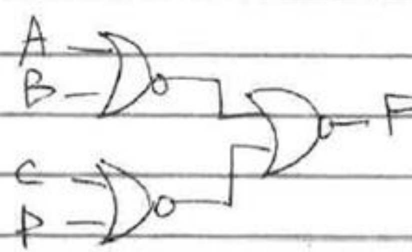
POS $F = (A+B)(C+D)$



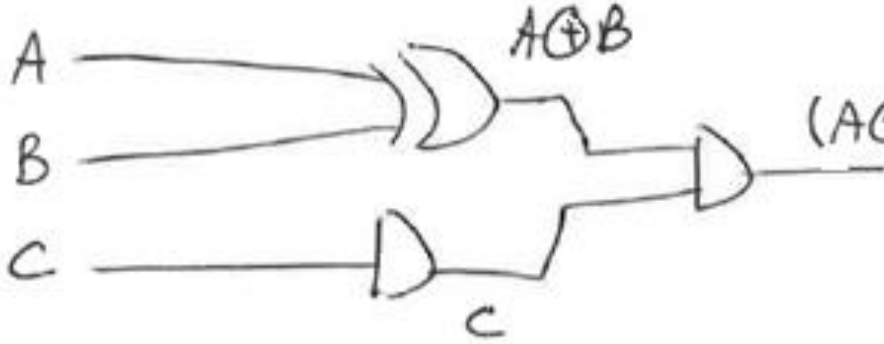
$F = \overline{\overline{F}} = \overline{\overline{(A+B)(C+D)}}$

=

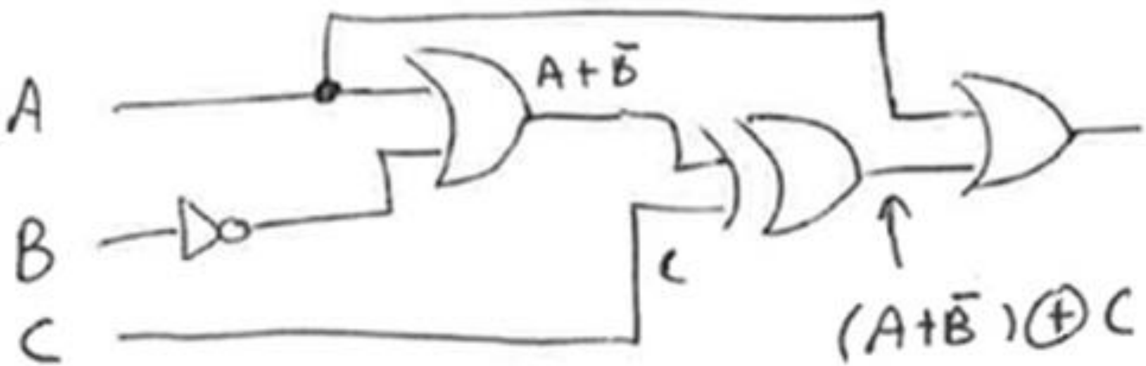
$= \overline{\overline{(A+B)} + \overline{(C+D)}}$



OR/AND Structure
= NOR/NOR structure



$$(A \oplus B)C = (A\bar{B} + \bar{A}B)C$$
$$= A\bar{B}C + \bar{A}BC$$

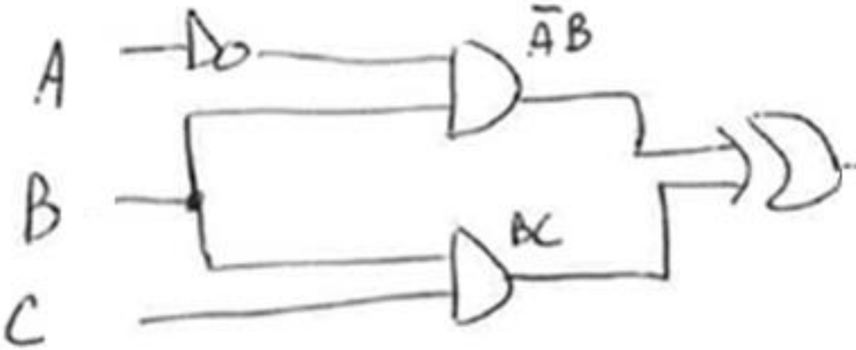


$$f = A + (A+\bar{B})\oplus C$$

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

$$= A + \bar{A}BC + A\bar{C} + \bar{B}\bar{C}$$

$$= A(1\cancel{+\bar{C}}) + \bar{A}BC + \bar{B}\bar{C}$$



$(\bar{A}B) \oplus (BC)$

$= \overline{\bar{A}B}\, BC + \bar{A}B\,\overline{BC}$

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

$= ABC + \cancel{\bar{B}BC} + \cancel{\bar{A}B\bar{B}} + \bar{A}B\bar{C}$

$= ABC + \bar{A}B\bar{C}$ In standard form

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

$= B(A \odot C)$

$$Y = \overline{\left(\overline{\overline{AB+C} + D}\right)\left(BC + \overline{D}\right)}$$

$$= \left(\overline{\overline{\overline{AB+C} + D}}\right) + \overline{\left(BC + \overline{D}\right)}$$

$$= \left(\overline{AB+C} + D\right) + \left(\overline{BC} \cdot \overline{\overline{D}}\right)$$

$$= \left(\overline{AB} \cdot \overline{C} + D\right) + \left(\overline{B} + \overline{C}\right)D$$

$$= \left(\left(\overline{A} + \overline{B}\right)\overline{C} + D\right) + \overline{B}D + \overline{C}D$$

$$= \overline{A}\,\overline{C} + \overline{B}\,\overline{C} + D + \overline{B}D + \overline{C}D$$

$$= \overline{A}\,\overline{C} + \overline{B}\,\overline{C} + D\left(1 + \overline{B} + \overline{C}\right)$$

$$= \overline{A}\,\overline{C} + \overline{B}\,\overline{C} + D$$

$$A \oplus B = \bar{A}B + A\bar{B}$$

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

$$= \left(\overline{A + B\bar{C}}\right)(A + C) + (A + B\bar{C})\left(\overline{A + C}\right)$$

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

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

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

$$= A\bar{A}\bar{B} + \bar{A}\bar{B}C + A\bar{A}C + \bar{A}CC + \bar{A}B\bar{C}$$

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

$$\bar{A}B \oplus B \oplus \bar{A}\bar{C}$$

$$= \left[\bar{A}B \oplus B\right] \oplus \bar{A}\bar{C}$$

$$= \left(\overline{\bar{A}B \oplus B}\right)\bar{A}\bar{C} + \left(\bar{A}B \oplus B\right)\overline{\bar{A}\bar{C}}$$

$$\searrow \; \bar{A}B \odot B$$

$$\boxed{A \odot B = AB + \bar{A}\bar{B}}$$

$$= \left[\overline{\bar{A}B}\,B + \overline{\overline{\bar{A}B}}\,\overline{B}\right]\bar{A}\bar{C} + \left(\left(\overline{\overline{\bar{A}B}}\right)B + \left(\bar{A}B\right)\bar{B}\right)\left(\bar{\bar{A}} + \bar{\bar{C}}\right)$$

$$= \left[\left(\bar{A} + \bar{B}\right)B + AB\bar{B}\right]\bar{A}\bar{C} + \left[ABB + \left[\left(\bar{A} + \bar{B}\right)\bar{B}\right]\left(A + C\right)\right]$$

$$= \left[\bar{A}B + \bar{B}B\right]\bar{A}\bar{C} + \left[AB + \left[\bar{A}\bar{B} + \bar{B}\bar{B}\right]\left(A + C\right)\right]$$

$$= \bar{A}B\bar{A}\bar{C} \quad + \quad \left[AB + \bar{A}A\bar{B} + A\bar{B} + \bar{A}\bar{B}C + \bar{B}C\right]$$

$$= \bar{A}B\bar{C} + AB + A\bar{B} + \bar{A}\bar{B}C + \bar{B}C$$

$$= \bar{A}B\bar{C} + A\left(B + \bar{B}\right) + \left(\bar{A} + 1\right)\bar{B}C$$

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