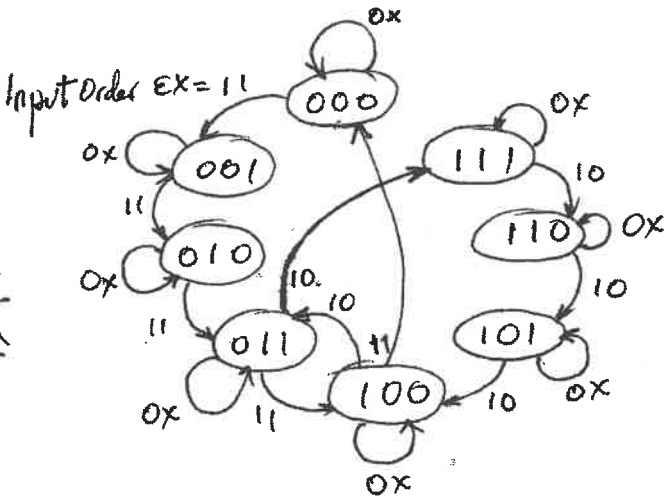
1.

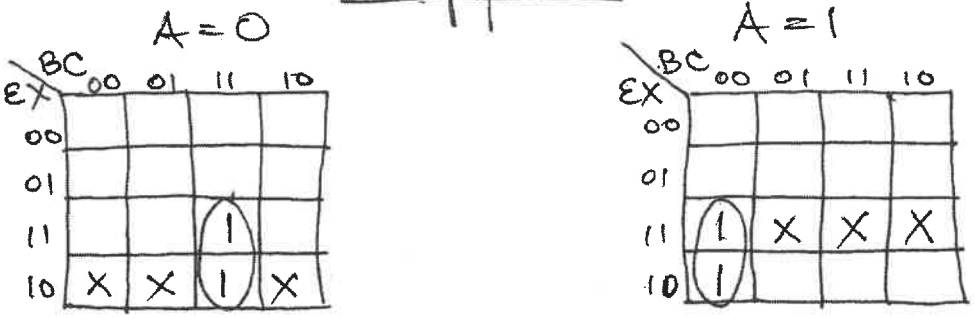
STATE TRANSITION DIAGRAM




STATE TRANSITION TABLE

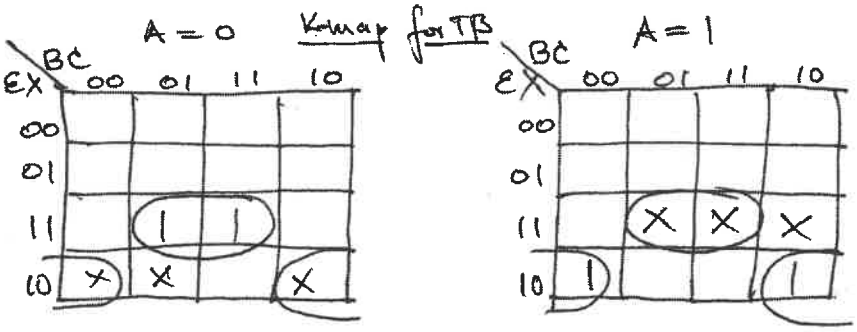
| Present State | | | Inputs | | Next State | | | Inputs Required | | |
|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | E | X | $A^+$ | $B^+$ | $C^+$ | TA | TB | TC |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 0 | X | X | X | X | X | X |
| 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 | 0 | X | X | X | X | X | X |
| 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 1 | 0 | X | X | X | X | X | X |
| 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 |
| 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 |
| 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 |
| 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| 1 | 0 | 1 | 1 | 1 | X | X | X | X | X | X |
| 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 |
| 1 | 1 | 0 | 1 | 1 | X | X | X | X | X | X |
| 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| 1 | 1 | 1 | 1 | 1 | X | X | X | X | X | X |

## K-map for TA



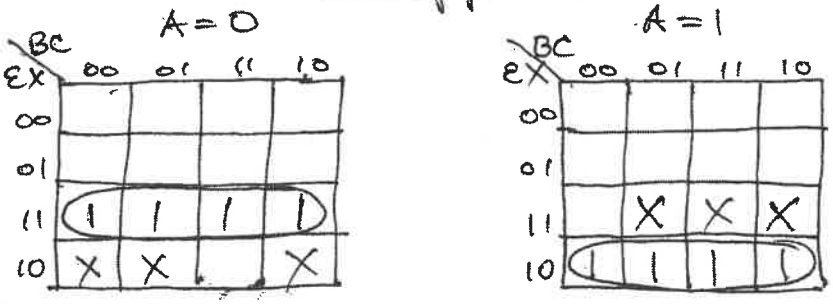

$$TA = \bar{A} \cdot B \cdot C \cdot E + A \cdot \bar{B} \cdot \bar{C} \cdot E$$

## K-map for TB

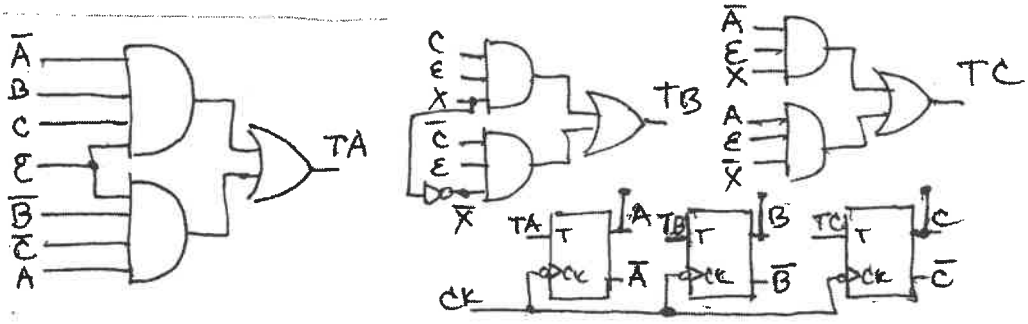



$$TB = C \cdot E \cdot X + \bar{C} \cdot E \cdot \bar{X}$$

## K-map for TC.




$$TC = \bar{A} \cdot E \cdot X + A \cdot E \cdot \bar{X}$$

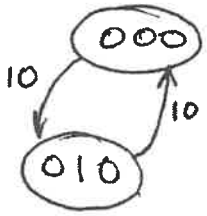


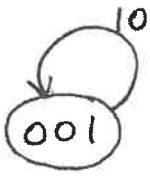
(b) & (c)

Assigning 1 to the X's of the implicants used the following is obtained for the unused states:

| A | B | C | E | X | TA | TB | TC | $A^+$ | $B^+$ | $C^+$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | Countdown unused states |
| 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | |
| 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | Countup unused states |
| 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | |
| 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | |

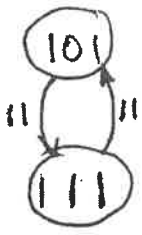
For the countdown unused states:
(000, 001, 010)




IT IS NOT SELF-STARTING
Since it never reaches one of the states in the countdown sequence.

For the countup unused states:
(101, 110, 111)





IT IS NOT SELF-STARTING
Since it never reaches one of the states in the countup sequence. It keeps cycling among the unused states.

2. (a) $K_A = Q_B$

$$J_A = Q_B \cdot \overline{I} + \overline{Q_B} \cdot I = Q_B \oplus I$$

$$T_B = Q_A \cdot \overline{I} + \overline{Q_B} \cdot \overline{I} = \overline{I}\left(Q_A + \overline{Q_B}\right)$$

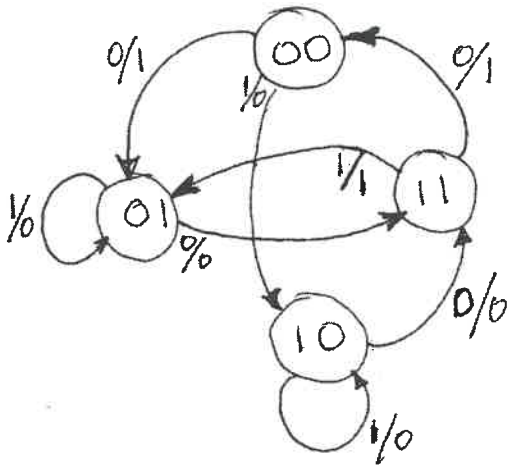
$$Z = Q_A \cdot Q_B + \overline{Q_A} \cdot \overline{Q_B} \cdot \overline{I}$$

(b) Mealy machine, output $Z$ depends on input $I$ directly

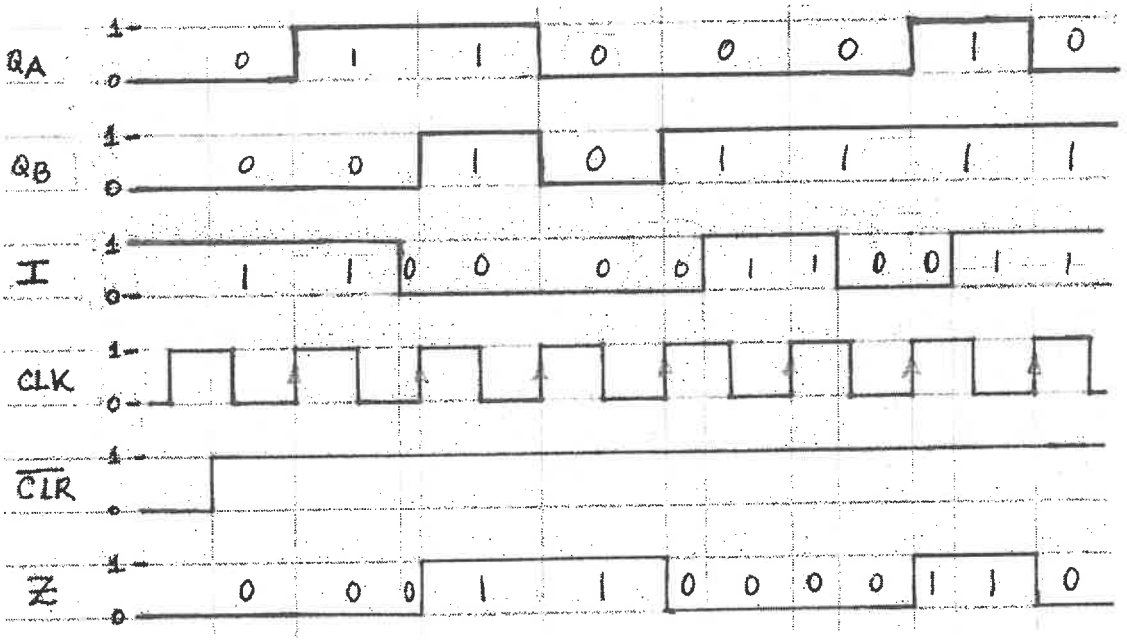
(c)

| $Q_A$ | $Q_B$ | $I$ | $J_A$ | $K_A$ | $T_B$ | $Q_A^+$ | $Q_B^+$ | $Z$ |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 |
| 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 |
| 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 |
| 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 |
| 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 |
| 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 |

(d)

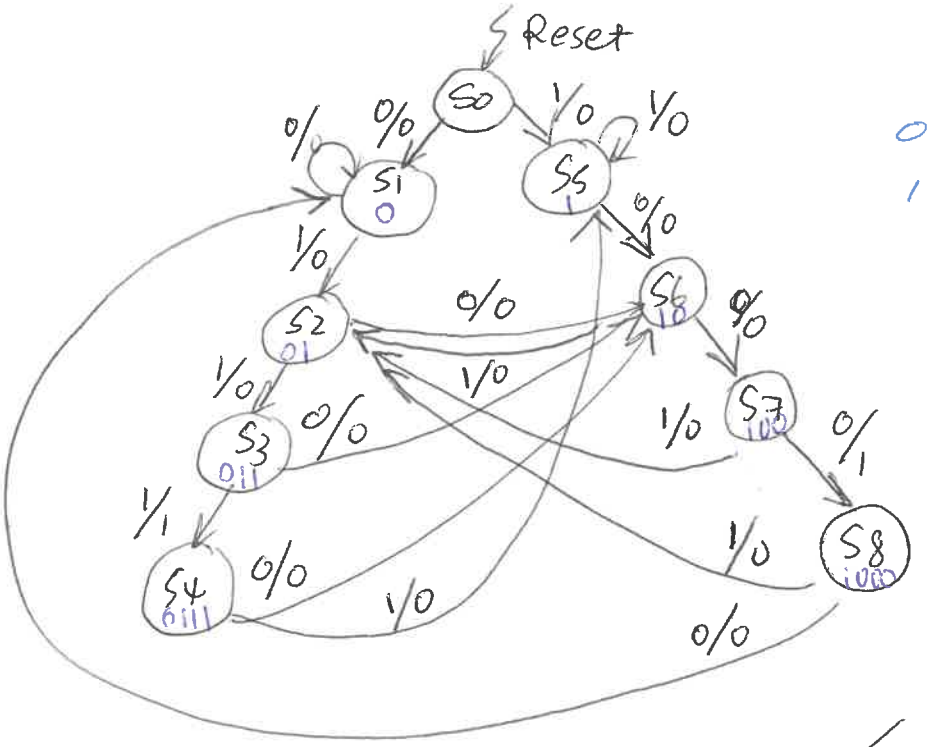


(e)


$Q_A$
0 1 1 0 0 0 1 0
$Q_B$
0 0 1 0 1 1 1 1
I
1 1 0 0 0 0 1 1 0 0 1 1
CLK
$\overline{CLR}$
Z
0 0 0 1 1 0 0 0 0 1 1 0

(a)

3




0111
1000

(b)

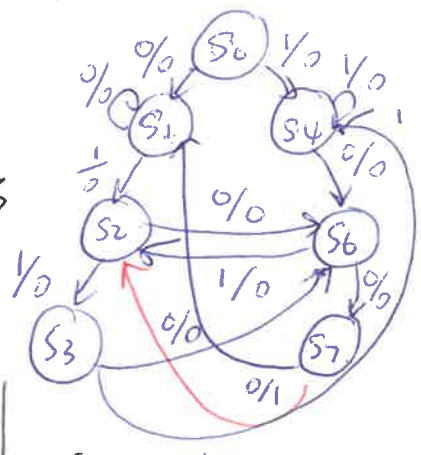
| Present State | Next State / output Y | |
|---|---|---|
| | x = 0 | x = 1 |
| S0 | S1 /0 | ~~S5~~ /0 S4/0 |
| S1 | S1 /0 | S2 /0 |
| S2 | S6 /0 | S3 /0 |
| S3 | S6 /0 | S4 /1 |
| S4 | S6 /0 | ~~S5~~ /0 S4/0 |
| S5 | S6 /0 | S5 /0 |
| S6 | S7 /0 | S2 /0 |
| S7 | ~~S8~~ /1 S1/1 | S2 /0 |
| ~~S8~~ | S1 /0 | S2 /0 |

3

| | S0 | S1 | S2 | S3 | S4 | S5 | S6 | S7 |
|---|---|---|---|---|---|---|---|---|
| S1 | ~~S2-S5~~ | | | | | | | |
| S2 | ~~S1-S6~~ S3-S5 | ~~S1-S6~~ S2-S3 | | | | | | |
| S3 | X | X | X | | | | | |
| S4 | ~~S1-S6~~ | ~~S1-S6~~ S2-S5 | ~~S3-S5~~ | X | | | | |
| S5 | ~~S1-S6~~ | ~~S1-S6~~ S2-S6 | ~~S3-S5~~ | X | ✓ | | | |
| S6 | ~~S1-S7~~ S2-S5 | ~~S1-S7~~ | ~~S6-S7~~ S2-S3 | X | ~~S2-S5~~ S6-S7 | ~~S6-S7~~ S2-S5 | | |
| S7 | X | X | X | X | X | X | X | |
| S8 | ~~S2-S5~~ | ✓ | ~~S1-S6~~ S2-S3 | X | ~~S1-S6~~ S2-S5 | ~~S1-S6~~ S2-S5 | ~~S1-S7~~ | X |

$S_1 \equiv S_8$

$S_4 \equiv S_5$



(c) Guideline #1 (States with same next state): for $x=0$, $\{S_0, S_1, S_7\}$, $\{S_2, S_3, S_4\}$; for $x=1$, $\{S_0, S_3, S_4\}$, $\{S_1, S_6, S_7\}$

Guideline #2 (Next-states of the same state): $\{S_1, S_4\}$, $\{S_1, S_2\}$, $\{S_6, S_3\}$, $\{S_6, S_4\}$, $\{S_7, S_2\}$, $\{S_1, S_2\}$

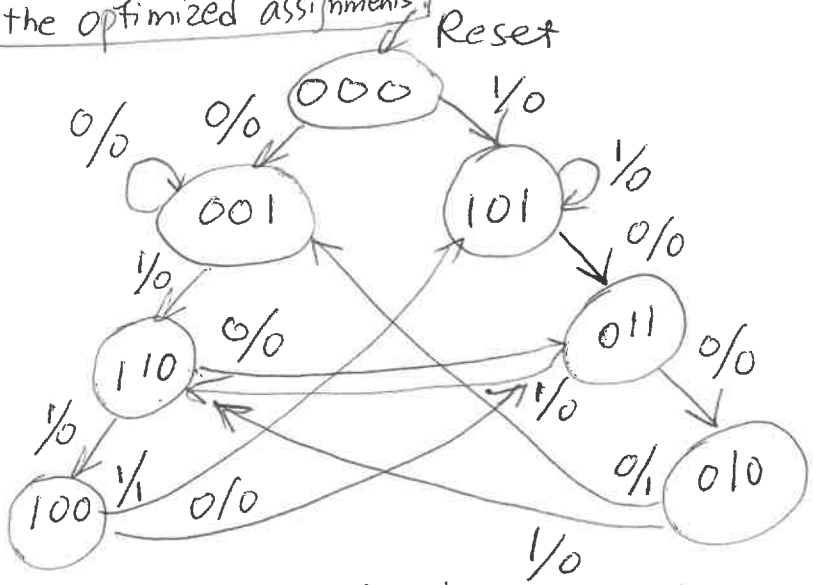
(3)

One possible assignment

| C \ AB | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | $S_0$ | $S_7$ | $S_2$ | $S_3$ |
| 1 | $S_1$ | $S_6$ | | $S_4$ |

| | A B C |
|---|---|
| $S_0$: | 0 0 0 |
| $S_1$: | 0 0 1 |
| $S_2$: | 1 1 0 |
| $S_3$: | 1 0 0 |
| $S_4$: | 1 0 1 |
| $S_6$: | 0 1 1 |
| $S_7$: | 0 1 0 |

Note: This assignment is just one of the optimized assignments.




(d)

| | A B C | $A^+ B^+ C^+$ x=0 | $A^+ B^+ C^+$ x=1 | Output Y x=0 | Output Y x=1 |
|---|---|---|---|---|---|
| $S_0$: | 0 0 0 | 0 0 1 | 1 0 1 | 0 | 0 |
| $S_1$: | 0 0 1 | 0 0 1 | 1 1 0 | 0 | 0 |
| $S_2$: | 1 1 0 | 0 1 1 | 1 0 0 | 0 | 0 |
| $S_3$: | 1 0 0 | 0 1 1 | 1 0 1 | 0 | 1 |
| $S_4$: | 1 0 1 | 0 1 1 | 1 0 1 | 0 | 0 |
| $S_6$: | 0 1 1 | 0 1 0 | 1 1 0 | 0 | 0 |
| $S_7$: | 0 1 0 | 0 0 1 | 1 1 0 | 1 | 0 |

| CX \ AB | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 0 | 0 | 0 | 0 |
| 01 | 1 | 1 | 1 | 1 |
| 11 | 1 | 1 | X | 1 |
| 10 | 0 | 0 | X | 0 |

$A^+ = X$

| CX \ AB | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 0 | 0 | 1 | 1 |
| 01 | 0 | 1 | 0 | 0 |
| 11 | 1 | 1 | X | 0 |
| 10 | 0 | 1 | X | 1 |

$B^+ = A\bar{X} + BC + \bar{A}BX + \bar{A}CX$

(4)

| CX \ AB | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 1 | 1 | 1 | 1 |
| 01 | 1 | 0 | 0 | 1 |
| 11 | 0 | 0 | X | 1 |
| 10 | 1 | 0 | X | 1 |

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

| CX \ AB | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 0 | 1 | 0 | 0 |
| 01 | 0 | 0 | 0 | 1 |
| 11 | 0 | 0 | X | 0 |
| 10 | 0 | 0 | X | 0 |

$Y = \bar{A}BC\bar{X} + A\bar{B}\bar{C}D$

(e)

(1)