(a) $F = \overline{X}\,\overline{Z} + XYZ$

X	Y	Z	$\overline{X}\,\overline{Z}$	XYZ	F
0	0	0	1	0	1
0	0	1	0	0	0
0	1	0	1	0	1
0	1	1	0	0	0
1	0	0	0	0	0
1	0	1	0	0	0
1	1	0	0	0	0
1	1	1	0	1	1

(b) $G = \overline{X} + X\overline{Y}Z + Y\overline{Z}$

X	Y	Z	$X\overline{Y}Z$	$Y\overline{Z}$	G
0	0	0	0	0	1
0	0	1	0	0	1
0	1	0	0	1	1
0	1	1	0	0	1
1	0	0	0	0	0
1	0	1	1	0	1
1	1	0	0	1	1
1	1	1	0	0	0

Q. 5

(a) $F = XYZ + \bar{X}Y$

X	Y	Z	XYZ	$\bar{X}Y$	F
0	0	0	0	0	0
0	0	1	0	0	0
0	1	0	0	1	1
0	1	1	0	1	1
1	0	0	0	0	0
1	0	1	0	0	0
1	1	0	0	0	0
1	1	1	1	0	1

(b) $F = \overline{(\overline{XYZ})(\overline{\bar{X}Y})}$

X	Y	Z	$\overline{XYZ}$	$\overline{\bar{X}Y}$	F
0	0	0	1	1	0
0	0	1	1	1	0
0	1	0	1	0	1
0	1	1	1	0	1
1	0	0	1	1	0
1	0	1	1	1	0
1	1	0	1	1	0
1	1	1	0	1	1

(c) The two circuits are equivalent

Q6

$$\overline{F} = \overline{B}D + \overline{A}B\overline{C} + ACD + \overline{A}BC$$

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

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

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

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

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

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

$$+ AB\overline{D} + A\overline{D} + \overline{B}\,\overline{D}$$

$$= \overline{B}\,\overline{D}\cancel{\left[1+\overline{A}+\overline{C}\right]} + A\overline{D}\cancel{\left[1+\overline{C}+B\right]}$$

$$+ AB\overline{C}$$

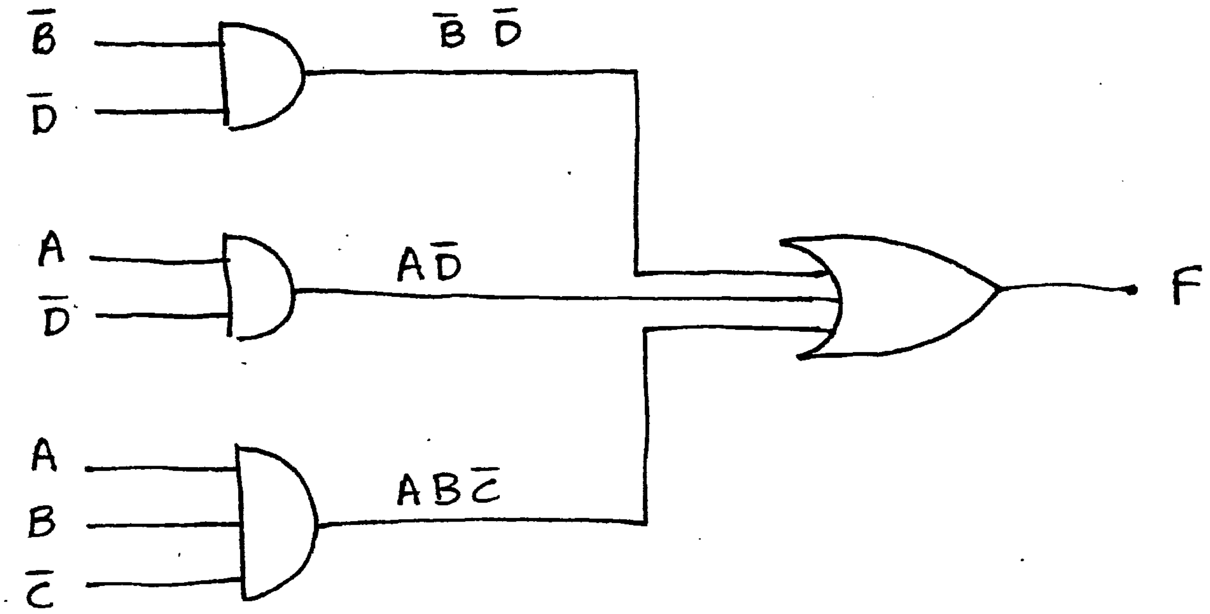
$$F = \overline{B}\,\overline{D} + A\overline{D} + AB\overline{C}$$

Q7.

A	B	C	D	$\bar{B}D$	$\bar{A}B\bar{C}$	ACD	$\bar{A}BC$	$\bar{F}$	F
0	0	0	0	0	0	0	0	0	1
0	0	0	1	1	0	0	0	1	0
0	0	1	0	0	0	0	0	0	1
0	0	1	1	1	0	0	0	1	0
0	1	0	0	0	1	0	0	1	0
0	1	0	1	0	1	0	0	1	0
0	1	1	0	0	0	0	1	1	0
0	1	1	1	0	0	0	1	1	0
1	0	0	0	0	0	0	0	0	1
1	0	0	1	1	0	0	0	1	0
1	0	1	0	0	0	0	0	0	1
1	0	1	1	1	0	1	0	1	0
1	1	0	0	0	0	0	0	0	1
1	1	0	1	0	0	0	0	0	1
1	1	1	0	0	0	0	0	0	1
1	1	1	1	0	0	1	0	1	0

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

Q8



$\overline{B}$
$\overline{D}$
$\overline{B}\ \overline{D}$
A
$\overline{D}$
$A\overline{D}$
A
B
$\overline{C}$
$AB\overline{C}$
F

Q9. (a) $AB C + \bar{A}\bar{B}C + \bar{A}BC + AB\bar{C} + \bar{A}\bar{B}\bar{C}$

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

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

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

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

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

(b) $\overline{((\overline{CD}) + A)} + A + CD + AB$

$$= CD\bar{A} + A + CD + AB$$

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

$$= CD + A$$

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

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

$$= (A+C)\Big[\underbrace{(A+C) + \underbrace{\bar{D} + D}_{1}}_{1}\Big](A+\bar{C}+D)(A+\bar{B})$$

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

$$= (AA + A\bar{C} + AD + CA + \cancel{C\bar{C}} + CD)(A+\bar{B})$$

$$= \Big[A\underbrace{\big[A + D + \underbrace{\bar{C} + C}_{1}\big]}_{1} + CD\Big](A+\bar{B})$$

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

Q.10

(a)

A B C	ABC	$\bar{A}\bar{B}C$	$\bar{A}BC$	$AB\bar{C}$	$\bar{A}\bar{B}\bar{C}$	OUTPUT
0 0 0	0	0	0	0	1	1
0 0 1	0	1	0	0	0	1
0 1 0	0	0	0	0	0	0
0 1 1	0	0	1	0	0	1
1 0 0	0	0	0	0	0	0
1 0 1	0	0	0	0	0	0
1 1 0	0	0	0	1	0	1
1 1 1	1	0	0	0	0	1

A B C	$B(A+C)$	$\bar{A}\bar{B}$	OUTPUT
0 0 0	0	1	1
0 0 1	0	1	1
0 1 0	0	0	0
0 1 1	1	1 ←?	1
1 0 0	0	0	0
1 0 1	0	0	0
1 1 0	1	0	1
1 1 1	1	0	1

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

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

(b)

ABCD	$\overline{\overline{C}D+A}$	A	CD	AB	Z	CD	A	Z*
0000	0	0	0	0	0	0	0	0
0001	0	0	0	0	0	0	0	0
0010	0	0	0	0	0	0	0	0
0011	1	0	1	0	1	1	0	1
0100	0	0	0	0	0	0	0	0
0101	0	0	0	0	0	0	0	0
0110	0	0	0	0	0	0	0	0
0111	1	0	1	0	1	1	0	1
1000	0	1	0	0	1	0	1	1
1001	0	1	0	0	1	0	1	1
1010	0	1	0	0	1	0	1	1
1011	0	1	1	0	1	1	1	1
1100	0	1	0	1	1	0	1	1
1101	0	1	0	1	1	0	1	1
1110	0	1	0	1	1	0	1	1
1111	0	1	1	1	1	1	1	1

$$Z = \overline{\overline{C}D + A} + A + CD + AB$$
$$Z^* = CD + A$$

By the truth table, $Z = Z^*$

(c)

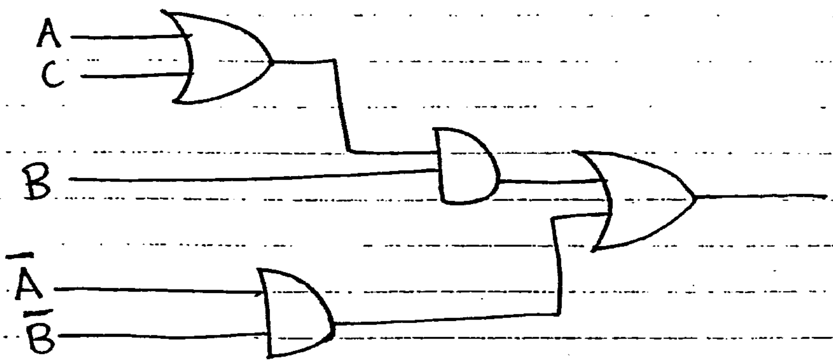
ABCD	A+C+D	$A+C+\overline{D}$	$A+\overline{C}+D$	$A+\overline{B}$	Z	A	$\overline{B}CD$	Z*
0000	0	1	1	1	0	0	0	0
0001	1	0	1	1	0	0	0	0
0010	1	1	0	1	0	0	0	0
0011	1	1	1	1	1	0	1	1
0100	0	1	1	1	0	0	0	0
0101	1	0	1	0	0	0	0	0
0110	1	1	0	0	0	0	0	0
0111	1	1	1	0	0	0	0	0
1000	1	1	1	1	1	1	0	1
1001	1	1	1	1	1	1	0	1
1010	1	1	1	1	1	1	0	1
1011	1	1	1	1	1	1	1	1
1100	1	1	1	1	1	1	0	1
1101	1	1	1	1	1	1	0	1
1110	1	1	1	1	1	1	0	1
1111	1	1	1	1	1	1	0	1

$Z = (A+C+D)(A+C+\overline{D})(A+\overline{C}+D)(A+\overline{B})$, $Z^* = A + \overline{B}CD$

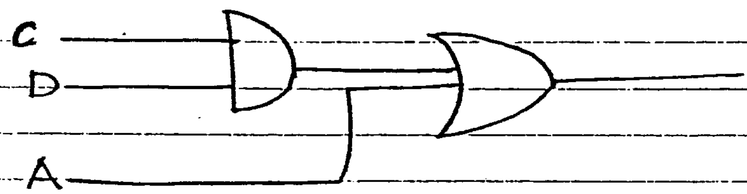
Again $Z = Z^*$

Q11

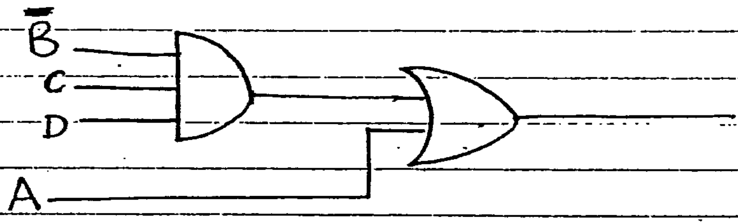
a)



b)



c)

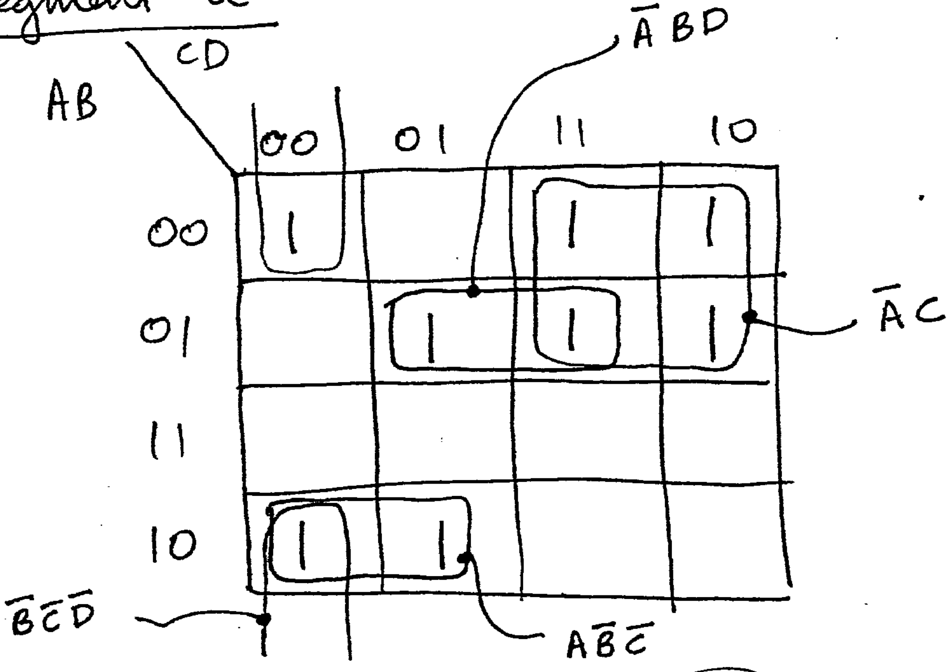


(6.)

	BINARY-CODED-DECIMAL				SEGMENT SELECTED						
	A	B	C	D	a	b	c	d	e	f	g
0	0	0	0	0	1	1	1	1	1	1	0
1	0	0	0	1	0	1	1	0	0	0	0
2	0	0	1	0	1	1	0	1	1	0	1
3	0	0	1	1	1	1	1	1	0	0	1
4	0	1	0	0	0	1	1	0	0	1	1
5	0	1	0	1	1	0	1	1	0	1	1
6	0	1	1	0	1	0	1	1	1	1	1
7	0	1	1	1	1	1	1	0	0	0	0
8	1	0	0	0	1	1	1	1	1	1	1
9	1	0	0	1	1	1	1	1	0	1	1
10	1	0	1	0							
11	1	0	1	1							
12	1	1	0	0							
13	1	1	0	1							
14	1	1	1	0							
15	1	1	1	1							

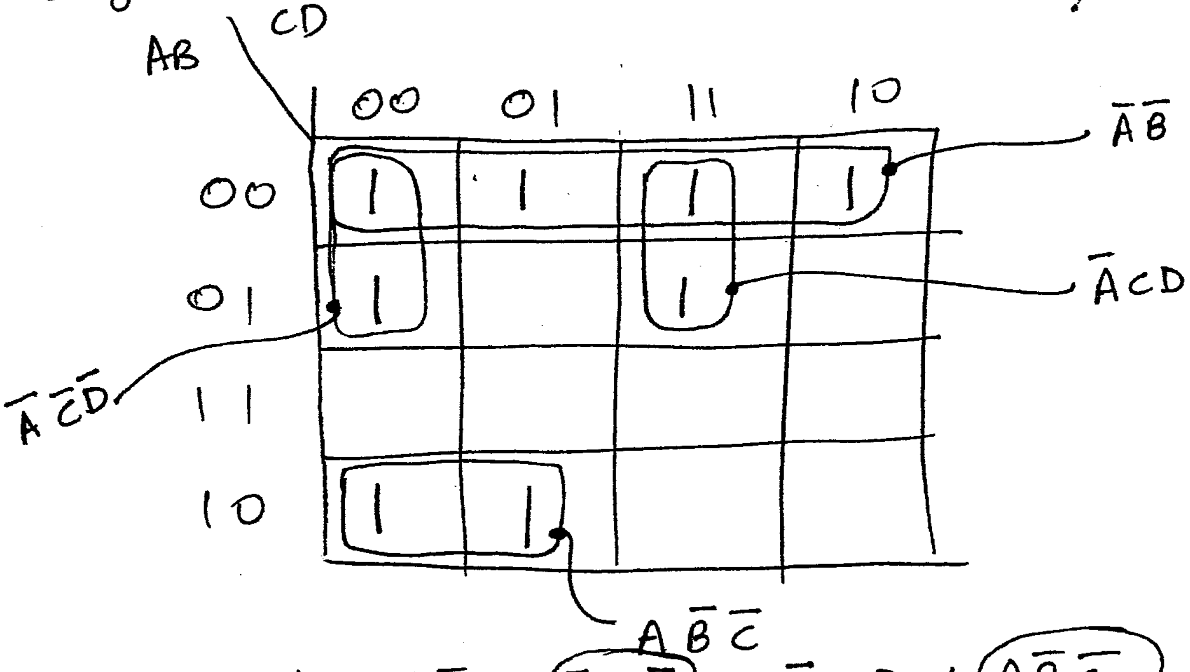
Note: Invalid input combinations (i.e., for 10, 11, 12, 13, 14, and 15) have been made equal to "0" for a blank display, rather than allowing them to be "don't care" states.

Note: product terms shared between more than one output have been circled segment a



$$a = \bar{A}C + \bar{A}BD + \bar{B}\bar{C}\bar{D} + A\bar{B}\bar{C}$$

segment b



$$b = \bar{A}\bar{B} + \bar{A}\bar{C}\bar{D} + \bar{A}CD + A\bar{B}\bar{C}$$

Note: rather than form the larger group using minterms 0, 1, 8, 9 to give $\bar{B}\bar{C}$ leave it as $A\bar{B}\bar{C}$ (ie minterms 8, 9) since these two occur quite often in other Karnaugh maps

segment c

$\bar{A}D$

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

$\bar{A}B$

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

$\bar{B}\bar{C}\bar{D}$

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

Once again rather than form larger groups (minterms 0, 1, 4, 5 and minterms 0, 1, 8, 9) we leave it as $A\bar{B}\bar{C}$ and $\bar{B}\bar{C}\bar{D}$ since we already need to form these product terms to implement segment "a".

segment d

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

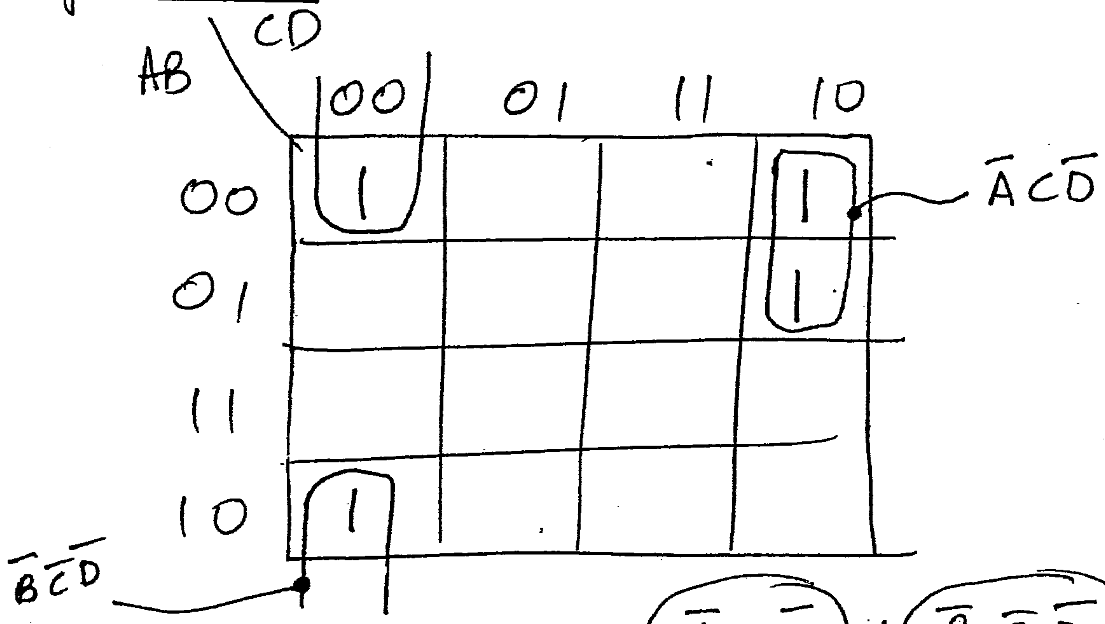
AB \ CD	00	01	11	10
00	1		1	1
01		1		1
11				
10	1	1		

$\bar{A}C\bar{D}$

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

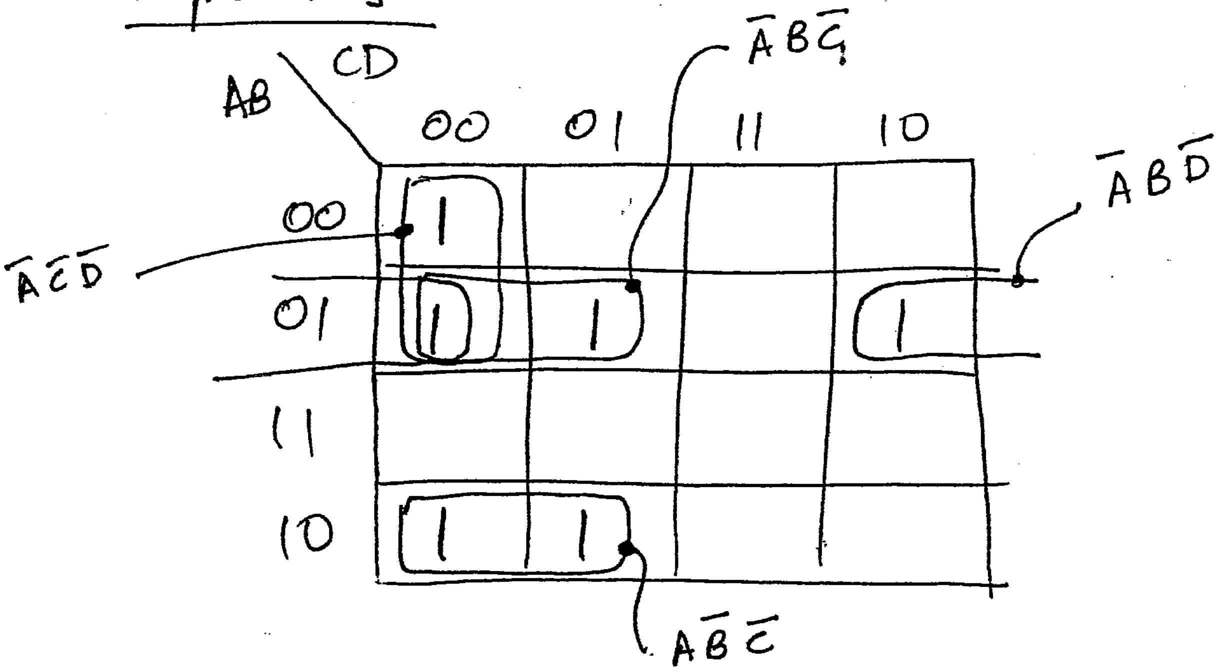
$$d = \bar{A}C\bar{D} + \bar{A}\bar{B}C + \bar{B}\bar{C}\bar{D} + A\bar{B}\bar{C} + \bar{A}B\bar{C}D$$

segment e



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

segment f



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

segment g.

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

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

$\bar{A}C\bar{D}$

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

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

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

Decimal Display Circuit