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Boolean Algebra

a.

$$x = ABC + \overline{A}C$$
$$= C(AB + \overline{A})$$
$$= C[(\overline{A} + B)(A + \overline{A})]$$
$$= C(\overline{A} + B)$$
$$= \overline{A}C + BC$$

b.

$$y = (Q + R)(\overline{Q} + \overline{R})$$
$$= Q\overline{Q} + Q\overline{R} + R\overline{Q} + R\overline{R}$$
$$= Q\overline{R} + \overline{Q}R$$

c.

$$w = ABC + A\overline{B}C + \overline{A}$$
$$= AC(B + \overline{B}) + \overline{A}$$
$$= AC + \overline{A}$$
$$= \overline{A} + \overline{C} + \overline{A}$$
$$= \overline{(\overline{A} + \overline{C})A}$$
$$= \overline{A\overline{A} + \overline{C}A}$$
$$= C + \overline{A}$$

d.

$$q = \overline{RST(R + S + T)} = \overline{(\overline{R}+\overline{S}+\overline{T})R.S.T} = \sum \overline{S.T}(\overline{R + R}) = \sum \overline{S.T.R} = \overline{S.T.R}$$

e.

$$x = \overline{A}\,\overline{B}\,\overline{C} + \overline{A}BC + ABC + A\overline{B}\,\overline{C} + A\overline{B}C$$
$$= (A + \overline{A})\overline{B}\,\overline{C} + (A + \overline{A})BC + A\overline{B}C$$
$$= \overline{B}\,\overline{C} + BC + A\overline{B}C$$
$$= \overline{B}\,\overline{C} + C(B + A\overline{B})$$

$$= \overline{B}\,\overline{C} + CB + CA$$

f.

$$z = (B + \overline{C})(\overline{B} + C) + \overline{\overline{A} + B + \overline{C}}$$
$$= B\overline{B} + BC + \overline{B}\,\overline{C} + \overline{C}C + A\overline{B}C$$
$$= BC + \overline{B}\,\overline{C} + A\overline{B}C$$
$$= BC + (\overline{B} + A\overline{B})\,\overline{C} + A\overline{B}C$$
$$= BC + \overline{B}\,\overline{C} + A\overline{B}\,\overline{C} + A\overline{B}C$$
$$= BC + \overline{B}\,\overline{C} + A\overline{B}$$

g.

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

h.

$$x = AB\overline{(\overline{C}D)} + \bar{A}BD + \bar{B}\bar{C}\bar{D}$$
$$x = AB(C + \bar{D}) + \bar{A}BD + \bar{B}\bar{C}\bar{D}$$
$$x = ABC + AB\bar{D} + \bar{A}BD + \bar{B}\bar{C}\bar{D}$$
$$x = ABC + \bar{A}BD + AB\bar{D} + \bar{B}\bar{C}\bar{D}$$
$$x = B(AC + \bar{A}D) + \bar{D}(AB + \bar{B}\bar{C})$$

K-map

1. $F(A,B,C) = \sum(1, 2, 3, 4, 6, 7)$:

	$\overline{C}$	C
$\bar{A}.\bar{B}$	0	1
$\bar{A}.B$	1	1
$A.B$	1	1
$A.\bar{B}$	1	0

1.png

$Therefore : X = B + A\bar{C} + \bar{A}C.$

2. $F(A,B,C,D) = \sum(1, 3, 4, 5, 6, 7, 12, 13)$:

	$\bar{C}.\bar{D}$	$\bar{C}.D$	$C.D$	$C.\bar{D}$
$\bar{A}.\bar{B}$	0	1	1	0
$\bar{A}.B$	1	1	1	1
$A.\bar{B}$	1	1	0	0
$A.B$	0	0	0	0

2.png

$Therefore : X = \bar{A}D + \bar{A}B + B\bar{C}.$

3.

$F(A,B,C,D) = \sum(2,5,7,8,10,12,13,15)$

	$\overline{C}.\overline{D}$	$\overline{C}.D$	$C.D$	$C.\overline{D}$
$\overline{A}.\overline{B}$	0 ₀	0 ₁	0 ₃	1 ₂
$\overline{A}.B$	0 ₄	1 ₅	1 ₇	0 ₆
$A.B$	1 ₁₂	1 ₁₃	1 ₁₅	0 ₁₄
$A.\overline{B}$	1 ₈	0 ₉	0 ₁₁	1 ₁₀

$\Rightarrow F(A,B,C,D) = BD + A\overline{C}.\overline{D} + \overline{B}C\overline{D}$

4.

$F(A,B,C,D) = \sum(0,6,8,9,10,11,13,14,15)$

Case 1

	$\overline{C}.\overline{D}$	$\overline{C}.D$	$C.D$	$C.\overline{D}$
$\overline{A}.\overline{B}$	1 0	0 1	0 3	0 2
$\overline{A}.B$	0 4	0 5	0 7	1 6
$A.B$	0 12	1 13	1 15	1 14
$A.\overline{B}$	1 8	1 9	1 11	1 10

$\Rightarrow F(A,B,C,D) = AD + AC + BC\overline{D} + \overline{B}.\overline{C}.\overline{D}$

Case 2

	$\overline{C}.\overline{D}$	$\overline{C}.D$	$C.D$	$C.\overline{D}$
$\overline{A}.\overline{B}$	1 0	0 1	0 3	0 2
$\overline{A}.B$	0 4	0 5	0 7	1 6
$A.B$	0 12	1 13	1 15	1 14
$A.\overline{B}$	1 8	1 9	1 11	1 10

$\Rightarrow F(A,B,C,D) = AD + A\overline{B} + BC\overline{D} + \overline{B}.\overline{C}.\overline{D}$

6

5.

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

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

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

$X = AC + AD + \bar{B}\bar{C}\bar{D} + \bar{A}B$

6.

DC/BA	$\overline{B}\overline{A}$	$\overline{B}A$	BA	B$\overline{A}$
$\overline{D}\overline{C}$	1	0	1	1
$\overline{D}C$	0	1	1	0
DC	1	1	1	1
D$\overline{C}$	1	0	1	1

$X = CA + DC + BA + \bar{C}\bar{A}$

DC/BA	$\overline{B}\overline{A}$	$\overline{B}A$	BA	B$\overline{A}$
$\overline{D}\overline{C}$	1	0	1	1
$\overline{D}C$	0	1	1	0
DC	1	1	1	1
D$\overline{C}$	1	0	1	1

$X = CA + DC + \bar{C}\bar{A} + \bar{C}B$

DC/BA	$\overline{B}\overline{A}$	$\overline{B}A$	BA	B$\overline{A}$
$\overline{D}\overline{C}$	1	0	1	1
$\overline{D}C$	0	1	1	0
DC	1	1	1	1
D$\overline{C}$	1	0	1	1

$X = CA + BA + \bar{C}\bar{A} + D\bar{A}$

DC/BA	$\overline{B}\overline{A}$	$\bar{B}A$	BA	B$\bar{A}$
$\overline{D}\overline{C}$	1	0	1	1
$\overline{D}\mathcal{C}$	0	1	1	0
DC	1	1	1	1
D$\bar{C}$	1	0	1	1

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

7.

DC/BA	$\overline{B}\overline{A}$	$\bar{B}A$	BA	B$\bar{A}$
$\overline{D}\overline{C}$	1	1	0	0
$\bar{D}C$	1	1	1	0
DC	0	1	1	1
D$\bar{C}$	1	0	0	1

$X = \bar{D}\bar{B} + CA + DCB + D\bar{C}\bar{A}$

DC/BA	$\overline{B}\overline{A}$	$\bar{B}A$	BA	B$\bar{A}$
$\overline{D}\overline{C}$	1	1	0	0
$\bar{D}C$	1	1	1	0
DC	0	1	1	1
D$\bar{C}$	1	0	0	1

$X = \bar{D}\bar{B} + CA + DB\bar{A} + D\bar{C}\bar{A}$

DC/BA	$\overline{B}\overline{A}$	$\bar{B}A$	BA	B$\bar{A}$
$\overline{D}\overline{C}$	1	1	0	0
$\bar{D}C$	1	1	1	0
DC	0	1	1	1
D$\bar{C}$	1	0	0	1

$X = \bar{D}\bar{B} + CA + DB\bar{A} + \bar{C}\bar{B}\bar{A}$

8.

- Case 1:

BA

		00	01	11	10
	00	X	1	X	1
	01	X	1	0	0
DC	11	1	X	X	X
	10	X	0	0	1

$$x_1 = \overline{C}\ \overline{A} + \overline{D}\ \overline{B} + DC$$

- Case 2:

BA

		00	01	11	10
	00	X	1	X	1
	01	X	1	0	0
DC	11	1	X	X	X
	10	X	0	0	1

$$x_2 = \overline{C}\ \overline{A} + \overline{D}\ \overline{C} + C\overline{B}$$

- Case 3:

11

BA

		00	01	11	10
	00	X	1	X	1
	01	X	1	0	0
DC	11	1	X	X	X
	10	X	0	0	1

$$x_3 = \overline{C}\ \overline{A} + \overline{D}\ \overline{B} + C\overline{B}$$

- Case 4:

BA

		00	01	11	10
	00	X	1	X	1
	01	X	1	0	0
DC	11	1	X	X	X
	10	X	0	0	1

$$x_4 = D\overline{A} + \overline{D}\ \overline{C} + \overline{D}\ \overline{B}$$

- Case 5:

12

BA

	00	01	11	10
00	X	1	X	1
01	X	1	0	0
11	1	X	X	X
10	X	0	0	1

DC

$$x_5 = D\overline{A} + \overline{D}\,\overline{C} + C\overline{B}$$

- Case 6:

BA

	00	01	11	10
00	X	1	X	1
01	X	1	0	0
11	1	X	X	X
10	X	0	0	1

DC

$$x_6 = \overline{C}\,\overline{A} + \overline{D}\,\overline{B} + \overline{B}\,\overline{A}$$

- Case 7:

13

BA

	00	01	11	10
00	X	1	X	1
01	X	1	0	0
11	1	X	X	X
10	X	0	0	1

DC

$$x_7 = D\overline{A} + \overline{C}\ \overline{A} + \overline{D}\ \overline{B}$$

KMap (cont)

1

1. F(A,B,C,D) = $\sum m(0, 1, 2, 5, 7, 8, 10, 14, 15) + d(3, 13)$

	$\overline{C}.\overline{D}$	$\overline{C}.D$	$C.D$	$C.\overline{D}$
$\overline{A}.\overline{B}$	1	1	x	1
$\overline{A}.B$	0	1	1	0
$A.B$	0	x	1	1
$A.\overline{B}$	1	0	0	1

F = B'D' + A'D + ABC

2

2)$F(A, B, C, D) = \prod M(1, 3, 4, 5, 11, 12, 14, 15).D(0, 6, 7, 8)$
Solution

	$\overline{C}\,\overline{D}$	$\overline{C}D$	CD	$C\overline{D}$
$\overline{A}\,\overline{B}$	x	0	0	1
$\overline{A}B$	0	0	x	x
AB	0	1	0	0
$A\overline{B}$	x	1	0	1

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

	$\overline{C}\,\overline{D}$	$\overline{C}D$	CD	$C\overline{D}$
$\overline{A}\,\overline{B}$	x	0	0	1
$\overline{A}B$	0	0	x	x
AB	0	1	0	0
$A\overline{B}$	x	1	0	1

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

3

3. $F(A,B,C,D) = \sum m(1,3,6,8,11,14) + d(2,4,5,13,15)$

F = A'B'D + B'CD + BCD' + AB'C'D'

F = AB'C'D' + A'B'D + BCD' + ACD

F = AB'C'D' + A'C'D + B'CD + BCD'

4.

- Case 1:

CD

	00	01	11	10
00	X	0	X	X
01	1	0	0	0
11	1	1	0	X
10	X	0	0	1

AB

$$x_1 = \overline{C}\,\overline{D} + A\overline{D} + AB\overline{C}$$

- Case 2:

CD

	00	01	11	10
00	X	0	X	X
01	1	0	0	0
11	1	1	0	X
10	X	0	0	1

AB

$$x_2 = \overline{C}\,\overline{D} + \overline{B}\,\overline{D} + AB\overline{C}$$

5.

$$BA$$

		00	01	11	10
	00	0	1	0	1
	01	1	X	X	0
DC	11	X	0	1	0
	10	1	0	0	X

F(D,C,B,A)
$= \prod M(0,3,6,9,11,13,14).D(5,7,10,12)$
$= (A + B + C + D)(\bar{B} + \bar{A} + C)(\bar{D} + \bar{A} + B)(\bar{C} + \bar{B} + A)$

6.

Case 1:

$$BA$$

		00	01	11	10
	00	1	1	0	0
	01	1	X	X	1
DC	11	X	0	X	1
	10	X	X	X	1

F(D,C,B,A)
$= \Sigma m(0,1,4,6,10,14) + d(5,7,8,9,11,12,15)$
$= \bar{D}\bar{B} + BC + BD$

Case 2:

$$BA$$

		00	01	11	10
	00	1	1	0	0
	01	1	X	X	1
DC	11	X	0	X	1
	10	X	X	X	1

F(D,C,B,A)
= Σm(0,1,4,6,10,14) + d(5,7,8,9,11,12,15)
= $\bar{B}\bar{D}$ + BD + $\bar{A}C$

Case 3:

$$BA$$

		00	01	11	10
	00	1	1	0	0
	01	1	X	X	1
DC	11	X	0	X	1
	10	X	X	X	1

F(D,C,B,A)
= Σm(0,1,4,6,10,14) + d(5,7,8,9,11,12,15)
= $\bar{B}\bar{D}$ + BD + $C\bar{D}$

Case 4:

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BA

	00	01	11	10
00	1	1	0	0
01	1	X	X	1
11	X	0	X	1
10	X	X	X	1

DC

F(D,C,B,A)
= Σm(0,1,4,6,10,14) + d(5,7,8,9,11,12,15)
= $\bar{B}\bar{D}$ + BC + $\bar{A}D$

Case 5:

BA

	00	01	11	10
00	1	1	0	0
01	1	X	X	1
11	X	0	X	1
10	X	X	X	1

DC

F(D,C,B,A)
= Σm(0,1,4,6,10,14) + d(5,7,8,9,11,12,15)
= $\bar{B}\bar{D}$ + $\bar{A}C$ + D$\bar{A}$

Case 6:

20

BA

	00	01	11	10
00	1	1	0	0
01	1	X	X	1
11	X	0	X	1
10	X	X	X	1

DC

F(D,C,B,A)
= Σm(0,1,4,6,10,14) + d(5,7,8,9,11,12,15)
= $\bar{B}\bar{D}$ + D$\bar{A}$ + C$\bar{D}$

Case 7:

BA

	00	01	11	10
00	1	1	0	0
01	1	X	X	1
11	X	0	X	1
10	X	X	X	1

DC

F(D,C,B,A)
= Σm(0,1,4,6,10,14) + d(5,7,8,9,11,12,15)
= $\bar{B}\bar{D}$ + BC + $\bar{C}D$

Case 8:

$$BA$$

	00	01	11	10
00	1	1	0	0
01	1	X	X	1
11	X	0	X	1
10	X	X	X	1

DC

F(D,C,B,A)
$= \Sigma m(0,1,4,6,10,14) + d(5,7,8,9,11,12,15)$
$= \bar{B}\bar{D} + \bar{C}D + C\bar{A}$

Case 9:

$$BA$$

	00	01	11	10
00	1	1	0	0
01	1	X	X	1
11	X	0	X	1
10	X	X	X	1

DC

F(D,C,B,A)
$= \Sigma m(0,1,4,6,10,14) + d(5,7,8,9,11,12,15)$
$= BD + C\bar{A} + \bar{B}\bar{C}$

Case 10:

22

$$BA$$

	00	01	11	10
00	1	1	0	0
01	1	X	X	1
11	X	0	X	1
10	X	X	X	1

DC

F(D,C,B,A)
= Σm(0,1,4,6,10,14) + d(5,7,8,9,11,12,15)
= BD + $\bar{C}\bar{B}$ + C$\bar{D}$

Case 11:

$$BA$$

	00	01	11	10
00	1	1	0	0
01	1	X	X	1
11	X	0	X	1
10	X	X	X	1

DC

F(D,C,B,A)
= Σm(0,1,4,6,10,14) + d(5,7,8,9,11,12,15)
= $\bar{C}\bar{B}$ + C$\bar{A}$ + D$\bar{A}$

Case 12:

23

$$BA$$

	00	01	11	10
00	1	1	0	0
01	1	X	X	1
11	X	0	X	1
10	X	X	X	1

DC

F(D,C,B,A)
= Σm(0,1,4,6,10,14) + d(5,7,8,9,11,12,15)
= $\bar{C}\bar{B} + C\bar{D} + D\bar{A}$

Case 13:

$$BA$$

	00	01	11	10
00	1	1	0	0
01	1	X	X	1
11	X	0	X	1
10	X	X	X	1

DC

= Σm(0,1,4,6,10,14) + d(5,7,8,9,11,12,15)
= $\bar{C}\bar{B} + C\bar{A} + D\bar{C}$

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7.

ED \ CB	00	01	11	10
00	0	1	1	0
01	0	X	0	0
11	X	0	0	1
10	0	0	0	1

$A= 0$

ED \ CB	00	01	11	10
00	0	X	0	0
01	0	1	0	0
11	1	X	0	1
10	0	0	0	1

$A= 1$

F(E,D,C,B,A)
$= \Sigma m(1,3,10,14,21,26,28,30) + d(5,12,17,29)$
$= \bar{C}B\bar{E} + C\bar{B}E + \bar{A}\bar{D}\bar{E}B + DE\bar{B}$

8. $F(A, B, C, D) = \Pi M(0, 2, 3, 4, 7, 8)$

- Case 1:

$$
\begin{array}{c|c|c|c|c}
 & \overline{C}.\overline{D} & \overline{C}D & CD & C\overline{D} \\
\hline
\overline{A}.\overline{B} & 0 & 1 & 0 & 0 \\
\hline
\overline{A}B & 0 & 1 & 0 & 1 \\
\hline
AB & 1 & 1 & 1 & 1 \\
\hline
A\overline{B} & 0 & 1 & 1 & 1 \\
\end{array}
$$

Groups	
$(0, 2)$	$A + B + D$
$(0, 4)$	$A + C + D$
$(0, 8)$	$B + C + D$
$(3, 7)$	$A + \overline{C} + \overline{D}$

Call x is the result of the simplification and we have:

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

- Case 2:

$$
\begin{array}{c|c|c|c|c|}
 & \overline{C}.\overline{D} & \overline{C}D & CD & C\overline{D} \\
\hline
\overline{A}.\overline{B} & 0 & 1 & 0 & 0 \\
\hline
\overline{A}B & 0 & 1 & 0 & 1 \\
\hline
AB & 1 & 1 & 1 & 1 \\
\hline
A\overline{B} & 0 & 1 & 1 & 1 \\
\hline
\end{array}
$$

Groups

$(3,2)$	$A + B + \overline{C}$
$(0,4)$	$A + C + D$
$(0,8)$	$B + C + D$
$(3,7)$	$A + \overline{C} + \overline{D}$

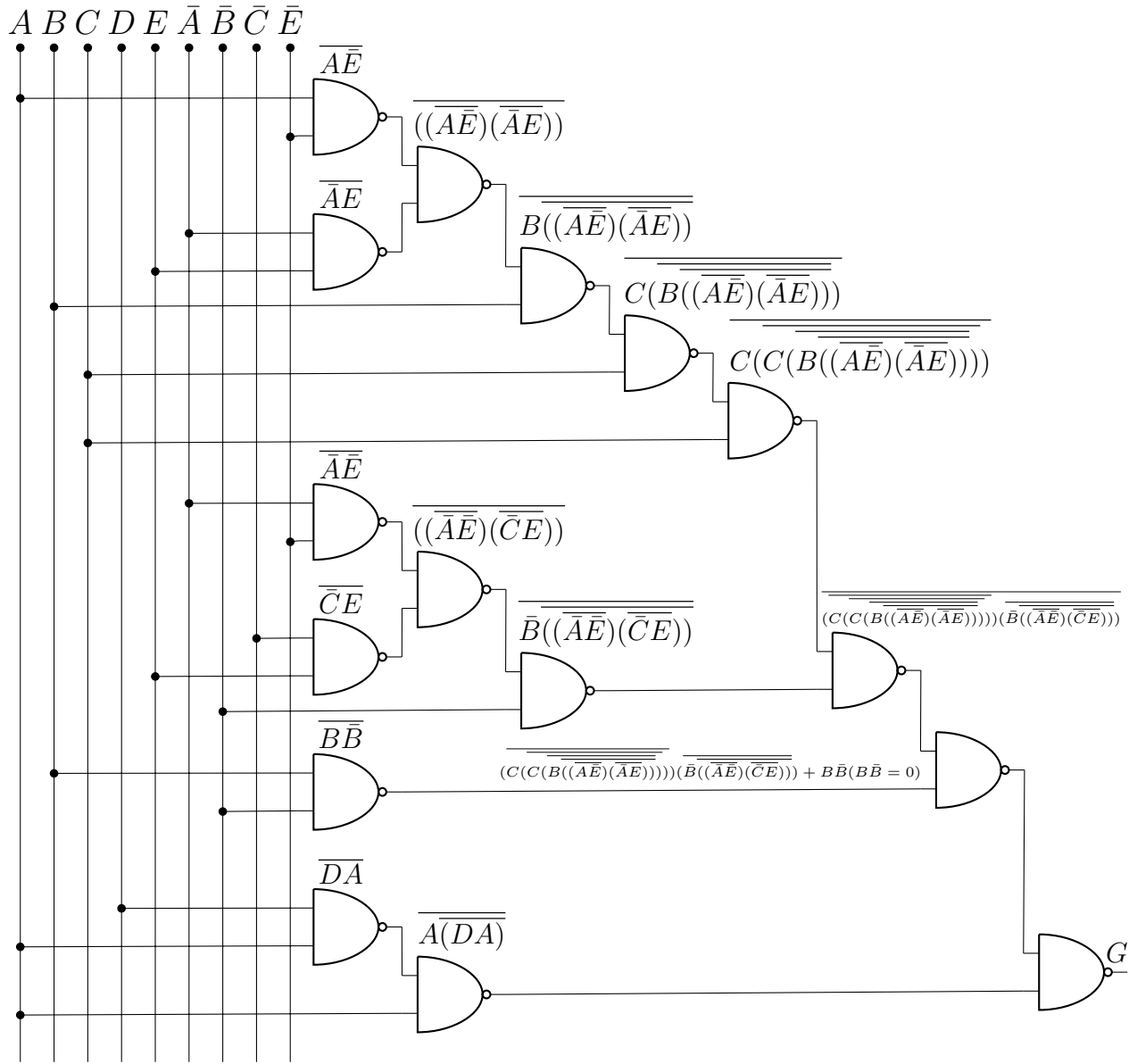Call x is the result of the simplification so we have:

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

2-input NAND gates.

The following function is in minimum sum of products form. Implement it using only two-input NAND gates. No gate may be used as a NOT gate.

1 — First way to simplify and draw G circuit

$$
\begin{aligned}
G &= ABC\bar{E} + \bar{A}\bar{B}\bar{E} + \bar{B}\bar{C}E + \bar{A}BCE + A\bar{D} \\
&= ABC\bar{E} + \bar{A}BCE + \bar{A}\bar{B}\bar{E} + \bar{B}\bar{C}E + A\bar{D} \\
&= BC(A\bar{E} + \bar{A}E) + \bar{B}(\bar{A}\bar{E} + \bar{C}E) + A\bar{D} \\
&= BC(A\bar{E} + \bar{A}E) + C\bar{C} + \bar{B}(\bar{A}\bar{E} + \bar{C}E) + B\bar{B} + A\bar{D} + A\bar{A} \\
&= C(\bar{C} + B(A\bar{E} + \bar{A}E)) + \bar{B}(\bar{A}\bar{E} + \bar{C}E) + B\bar{B} + A(\bar{D} + \bar{A}) \\
&= \overline{\overline{(C(C.(B(\overline{(A\bar{E}).(\bar{A}E)}))))}.\overline{(\bar{B}(\overline{(\bar{A}\bar{E}).(\bar{C}E)}))}.\overline{((B\bar{B}))}.\overline{(A(\overline{DA}))}} \\
&= \overline{[\overline{(C(C.(B(\overline{(A\bar{E}).(\bar{A}E)}))))}.\overline{(\bar{B}(\overline{(\bar{A}\bar{E}).(\bar{C}E)}))} + (B\bar{B})].\overline{(A(\overline{DA}))}} \\
&= \overline{[\overline{(C(C.(B(\overline{(A\bar{E}).(\bar{A}E)}))))}.\overline{(\bar{B}(\overline{(\bar{A}\bar{E}).(\bar{C}E)}))}].\overline{(A(\overline{DA}))}}
\end{aligned}
\tag{1}
$$

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

$\overline{A\bar{E}}$

$\overline{((\overline{A\bar{E}})(\overline{\bar{A}E}))}$

$\overline{\bar{A}E}$

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

$\overline{C(\overline{B((\overline{A\bar{E}})(\overline{\bar{A}E}))})}$

$\overline{C(C(\overline{B((\overline{A\bar{E}})(\overline{\bar{A}E}))}))}$

$\overline{\bar{A}\bar{E}}$

$\overline{((\overline{\bar{A}\bar{E}})(\overline{\bar{C}E}))}$

$\overline{\bar{C}E}$

$\overline{\bar{B}((\overline{\bar{A}\bar{E}})(\overline{\bar{C}E}))}$

$\overline{\bar{B}\bar{B}}$

$\overline{(C(C(\overline{B((\overline{A\bar{E}})(\overline{\bar{A}E}))})))(\overline{\bar{B}((\overline{\bar{A}\bar{E}})(\overline{\bar{C}E}))})}$

$\overline{(C(C(B((\overline{A\bar{E}})(\overline{\bar{A}E})))))(\bar{B}((\overline{\bar{A}\bar{E}})(\overline{\bar{C}E}))) + B\bar{B}(B\bar{B} = 0)}$

$\overline{D\bar{A}}$

$\overline{A\overline{(D\bar{A})}}$

G

2 — Second way to simplify and draw G circuit

$$
\begin{aligned}
G &= ABC\bar{E} + \bar{A}\bar{B}\bar{E} + \bar{B}\bar{C}E + \bar{A}BCE + A\bar{D} \\
&= ABC\bar{E} + \bar{A}\bar{B}\bar{E} + \bar{B}\bar{C}E + \bar{A}BCE + A\bar{D}(B + \bar{B}) \\
&= ABC\bar{E} + \bar{A}\bar{B}\bar{E} + \bar{B}\bar{C}E + \bar{A}BCE + A\bar{D}B + A\bar{D}\bar{B} \\
&= A\bar{D}\bar{B} + \bar{A}\bar{B}\bar{E} + \bar{B}\bar{C}E + \bar{A}BCE + A\bar{D}B + ABC\bar{E} \\
&= \bar{B}(\bar{A}\bar{E} + \bar{C}E + A\bar{D}) + B(AC\bar{E} + \bar{A}CE + A\bar{D}) \\
&= \bar{B}(\bar{A}\bar{E} + \bar{C}E(A + \bar{A}) + A\bar{D}) + B(AC\bar{E} + \bar{A}CE + A\bar{D}) \\
&= \bar{B}(\bar{A}\bar{E} + \bar{C}EA + \bar{C}E\bar{A} + A\bar{D}) + B(C(A\bar{E} + \bar{A}E) + A\bar{D}) \\
&= \bar{B}(\bar{A}\bar{E} + \bar{C}E\bar{A} + \bar{C}EA + A\bar{D}) + B(C(A\bar{E} + \bar{A}E) + A\bar{D}) \\
&= \bar{B}(\bar{A}(\bar{E} + \bar{C}E) + A(\bar{C}E + \bar{D})) + B(C(A\bar{E} + \bar{A}E) + A\bar{D}) \\
&= \bar{B}(\bar{A}(\overline{\bar{\bar{E}}.\overline{\bar{C}E}}) + A(\overline{\overline{\bar{C}E}.\overline{\bar{D}}})) + B(C(\overline{\overline{A\bar{E}}.\overline{\bar{A}E}}) + A\bar{D}) \\
&= \bar{B}(\overline{\bar{A}(\overline{\bar{\bar{E}}.\overline{\bar{C}E}})}.\overline{A(\overline{\overline{\bar{C}E}.\overline{\bar{D}}})}) + B(\overline{C(\overline{\overline{A\bar{E}}.\overline{\bar{A}E}})}.\overline{A\bar{D}}) \\
&= \bar{B}(\overline{\bar{A}(\overline{\bar{\bar{E}}.\overline{\bar{C}E}})}.\overline{A(\overline{\overline{\bar{C}E}.\overline{\bar{D}}})}).B(\overline{C(\overline{\overline{A\bar{E}}.\overline{\bar{A}E}})}.\overline{A\bar{D}})
\end{aligned}
\tag{2}
$$
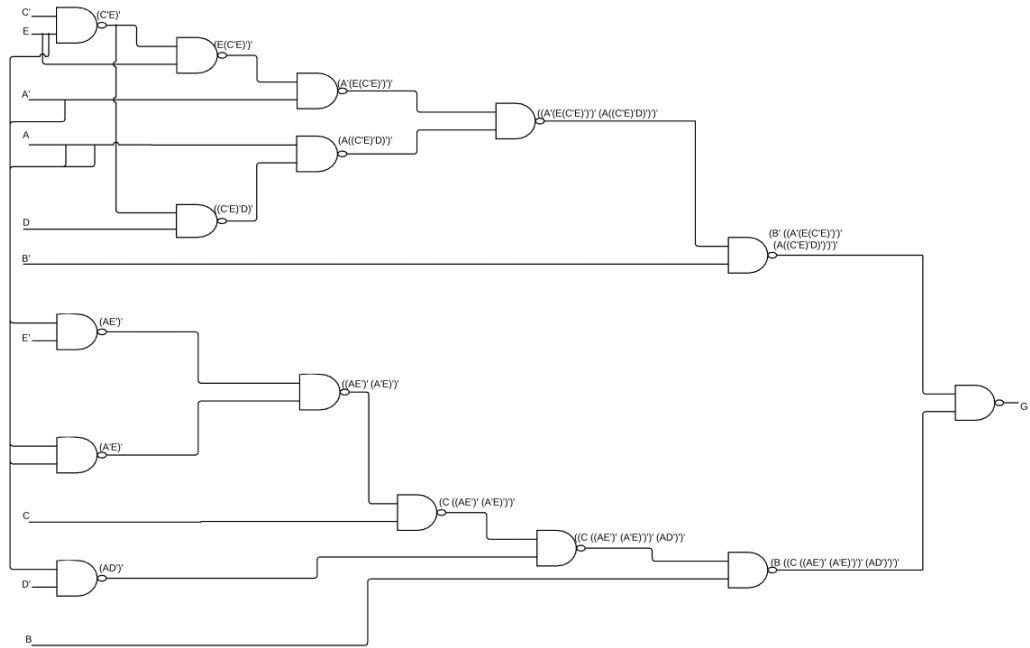
$$K = \bar{x}\bar{y}b + \bar{x}y\bar{b} + x\bar{y}\bar{b} + xyb$$
$$= \bar{x}\bar{y}b + x\bar{y}\bar{b} + \bar{x}y\bar{b} + xyb$$
$$= \bar{y}(\bar{x}b + x\bar{b}) + y(\bar{x}\bar{b} + xb) \tag{3}$$
$$= (\overline{\bar{y}(\overline{(\overline{\bar{x}b})\cdot(\overline{x\bar{b}})})}) \cdot (\overline{y(\overline{(\overline{\bar{x}\bar{b}})\cdot(\overline{xb})})})$$