Code Converters

Contd

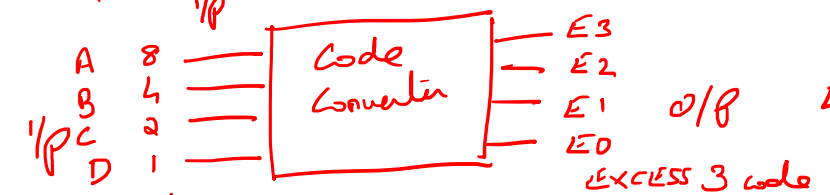
Decimal Digit	8421 (BCD)	Excess 3	84-2-1	2421	Gray Code
0	0 0 0 0 m0	0 0 1 1 m3	0 0 0 0 m0	0 0 0 0 m0	0 0 0 0 m0
1	0 0 0 1 m1	0 1 0 0 m4	0 1 1 1 m7	0 0 0 1 m1	0 0 0 1 m1
2	0 0 1 0 m2	0 1 0 1 m5	0 1 1 0 m6	0 0 1 0 m2	0 0 1 1 m3
3	0 0 1 1 m3	0 1 1 0 m6	0 1 0 1 m5	0 0 1 1 m3	0 0 1 0 m2
4	0 1 0 0 m4	0 1 1 1 m7	0 1 0 0 m4	0 1 0 0 m4	0 1 1 0 m6
5	0 1 0 1 m5	1 0 0 0 m8	1 0 1 1 m11	1 0 1 1 m11	0 1 1 1 m7
6	0 1 1 0 m6	1 0 0 1 m9	1 0 1 0 m10	1 1 0 0 m12	0 1 0 1 m5
7	0 1 1 1 m7	1 0 1 0 m10	1 0 0 1 m9	1 1 0 1 m13	0 1 0 0 m4
8	1 0 0 0 m8	1 0 1 1 m11	1 0 0 0 m8	1 1 1 0 m14	1 0 0 0 m8
9	1 0 0 1 m9	1 1 0 0 m12	1 1 1 1 m15	1 1 1 1 m15	1 0 0 1 m9
-	1 0 1 0 m10	0 0 0 0 m0	0 0 0 1 m1	0 1 0 1 m5	1 0 1 0 m10
-	1 0 1 1 m11	0 0 0 1 m1	0 0 1 0 m2	0 1 1 0 m6	1 0 1 1 m11
-	1 1 0 0 m12	0 0 1 0 m2	0 0 1 1 m3	0 1 1 1 m7	1 1 0 0 m12
-	1 1 0 1 m13	1 1 0 1 m13	1 1 0 0 m12	1 0 0 0 m8	1 1 0 1 m13
-	1 1 1 0 m14	1 1 1 0 m14	1 1 0 1 m13	1 0 0 1 m9	1 1 1 0 m14
-	1 1 1 1 m15	1 1 1 1 m15	1 1 1 0 m14	1 0 1 0 m10	1 1 1 1 m15

10 Valid Decimal Symbols

Highlighted texts are invalid combinations at input

- Design a code converter to convert a decimal digit represented in 8421 code to a decimal digit represented in Excess 3 code.

Decimal digit	8 4 2 1 A B C D	Excess 3 code E3 E2 E1 E0
0	0 0 0 0 m_0	0 0 1 1
1	0 0 0 1 m_1	0 1 0 0
2	0 0 1 0 m_2	0 1 0 1
3	0 0 1 1 m_3	0 1 1 0
4	0 1 0 0 m_4	0 1 1 1
5	0 1 0 1 m_5	1 0 0 0
6	0 1 1 0 m_6	1 0 0 1
7	0 1 1 1 m_7	1 0 1 0
8	1 0 0 0 m_8	1 0 1 1
9	1 0 0 1 m_9	1 1 0 0
Don't cares	1010, 1011, 1100, 1101, 1110, 1111	ϕ ϕ ϕ ϕ ----------



$E_3(A,B,C,D)$
$E_2(A,B,C,D)$
$E_1(A,B,C,D)$
$E_0(A,B,C,D)$

BCD code (8421) $E_3(A,B,C,D)$ — Excess 3 code — SOP

$E_3 = \sum_m 5,6,7,8,9 + \sum_\phi 10,11,12,13,14,15$ → SOP → NAND

$E_3 = \prod_M 0,1,2,3,4 \cdot \prod_d 10,11,12,13,14,15$ → POS → NOR

$E_2 = \sum_m 1,2,3,4,9 + \sum_\phi 10,11,12,13,14,15$

$E_1 = \sum_m 0,3,4,7,8 + \sum_\phi 10,11,12,13,14,15$

$E_0 = \sum_m 0,2,4,6,8 + \sum_\phi 10,11,12,13,14,15$

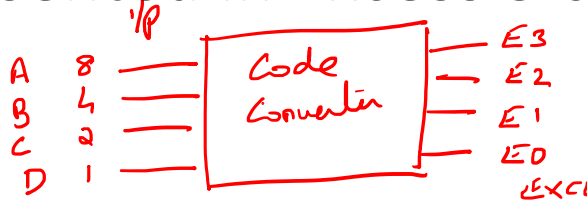
Pls note: I/P → 4 Variable → 4-Variable K-MAP

How many K-maps? observe O/P → 4 Variable

We require to solve 4 K-maps one each for O/P E_3, E_2, E_1, E_0

- Design a code converter to convert a decimal digit represented in 8421 code to a decimal digit represented in Excess 3 code.

Decimal Digit	8421 (BCD) A B C D	Excess 3 $E_3\ E_2\ E_1\ E_0$
0	0 0 0 0 $_{m0}$	0 0 1 1
1	0 0 0 1 $_{m1}$	0 1 0 0
2	0 0 1 0 $_{m2}$	0 1 0 1
3	0 0 1 1 $_{m3}$	0 1 1 0
4	0 1 0 0 $_{m4}$	0 1 1 1
5	0 1 0 1 $_{m5}$	1 0 0 0
6	0 1 1 0 $_{m6}$	1 0 0 1
7	0 1 1 1 $_{m7}$	1 0 1 0
8	1 0 0 0 $_{m8}$	1 0 1 1
9	1 0 0 1 $_{m9}$	1 1 0 0
-	1 0 1 0 $_{m10}$	-
-	1 0 1 1 $_{m11}$	-
-	1 1 0 0 $_{m12}$	-
-	1 1 0 1 $_{m13}$	-
-	1 1 1 0 $_{m14}$	-
-	1 1 1 1 $_{m15}$	-



$E_3 = \sum_m 5, 6, 7, 8, 9 + \sum_\phi 10, 11, 12, 13, 14, 15$ → SOP (NAND)

$E_3 = \prod_M 0, 1, 2, 3, 4 \cdot \prod_d 10, 11, 12, 13, 14, 15$ → POS (NOR)

Highlighted texts are invalid combinations at input

SOP

$E_2 = \sum_m 1, 2, 3, 4, 9 + \sum_\phi 10, 11, 12, 13, 14, 15$

$E_1 = \sum_m 0, 3, 4, 7, 8 + \sum_\phi 10, 11, 12, 13, 14, 15$

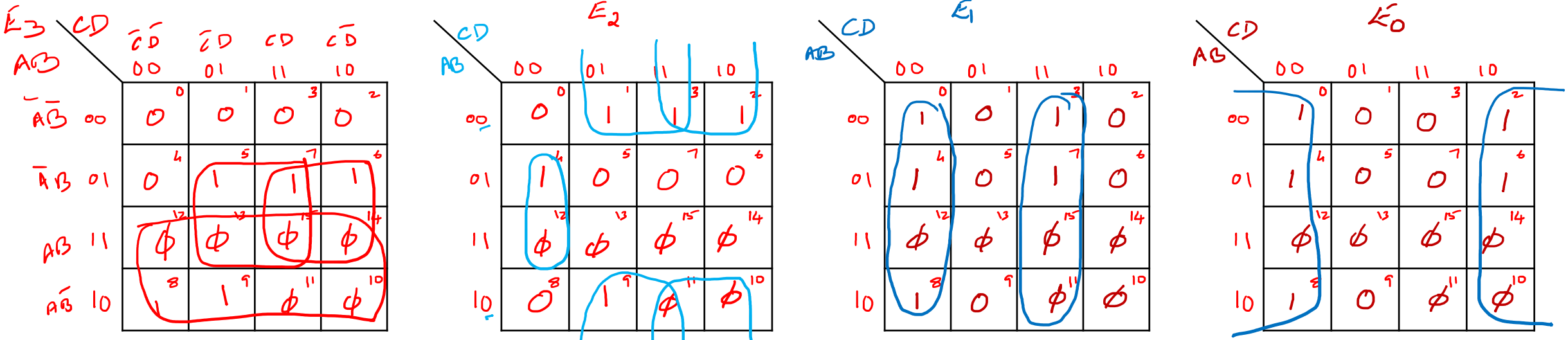
$E_0 = \sum_m 0, 2, 4, 6, 8 + \sum_\phi 10, 11, 12, 13, 14, 15$

Pls note: I/p → 4 Variable → 4-Variable K-MAP

How many K-maps? observe o/p → 4 Variable

We require ~~to~~ solve 4 K-maps one each for o/p E_3, E_2, E_1, E_0

I/p
ϕ 1010
ϕ 1011
ϕ 1100
ϕ 1101
ϕ 1110
ϕ 1111



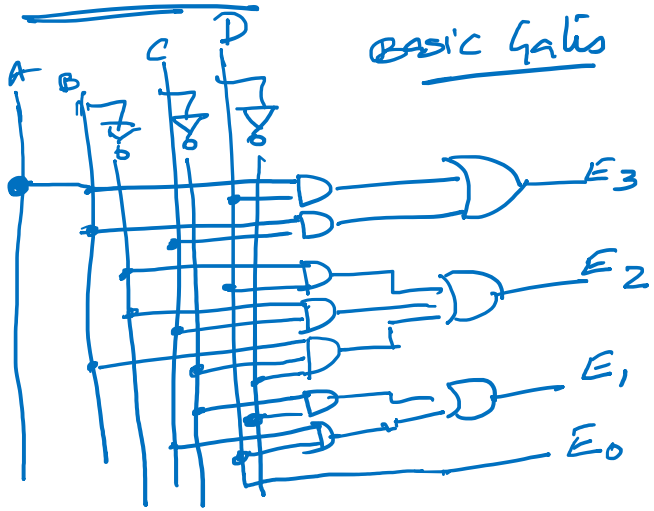
SOP

$E_3 = \sum(5,6,7,8,9) + \sum_{\phi}(10,11,12,13,14,15)$

$E_3 = A + BD + BC$ ✓ SOP

$\bar{E}_3 = \overline{A + BD + BC}$

$E_3 = \bar{A} \cdot \overline{BD} \cdot \overline{BC}$



BASIC Gates

$E_2 = \bar{B}D + B\bar{C} + BC\bar{D}$ ✓

$\bar{E}_2 = \overline{\bar{B}D + B\bar{C} + BC\bar{D}}$

$E_2 = \overline{\bar{B}D} \cdot \overline{B\bar{C}} \cdot \overline{BC\bar{D}}$

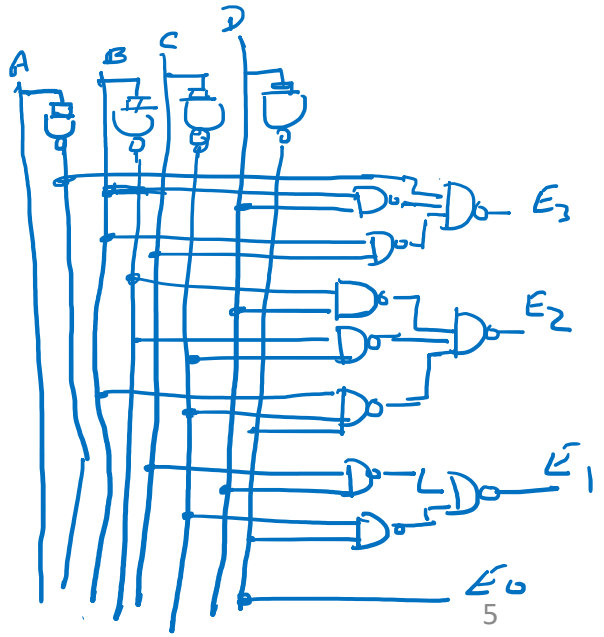
NAND ONLY

$E_1 = \bar{C}\bar{D} + CD$ ✓

$\bar{E}_1 = \overline{\bar{C}\bar{D} + CD}$

$E_1 = \overline{\bar{C}\bar{D}} \cdot \overline{CD}$

$E_0 = \bar{D}$ ✓



Design a code converter to convert a decimal digit represented in 8 4 2 1 code to a decimal digit represented in 8 4 -2 -1 code.

Decimal Digit	8421 (BCD) A B C D	84-2-1 Y3 Y2 Y1 Y0
0	0 0 0 0 m0	0 0 0 0
1	0 0 0 1 m1	0 1 1 1
2	0 0 1 0 m2	0 1 1 0
3	0 0 1 1 m3	0 1 0 1
4	0 1 0 0 m4	0 1 0 0
5	0 1 0 1 m5	1 0 1 1
6	0 1 1 0 m6	1 0 1 0
7	0 1 1 1 m7	1 0 0 1
8	1 0 0 0 m8	1 0 0 0
9	1 0 0 1 m9	1 1 1 1
-	1 0 1 0 m10	-
-	1 0 1 1 m11	-
-	1 1 0 0 m12	-
-	1 1 0 1 m13	-
-	1 1 1 0 m14	-
-	1 1 1 1 m15	-

Invalid

don't cares

minterms

$Y_3 = \sum_m 5, 6, 7, 8, 9 + \sum_\phi 10, 11, 12, 13, 14, 15$

$Y_2 = \sum_m 1, 2, 3, 4, 9 + \sum_\phi 10, 11, 12, 13, 14, 15$

$Y_1 = \sum_m 1, 2, 5, 6, 9 + \sum_\phi 10, 11, 12, 13, 14, 15$

$Y_0 = \sum_m 1, 3, 5, 7, 9 + \sum_\phi 10, 11, 12, 13, 14, 15$

maxterms

$Y_3 = \prod 0, 1, 2, 3, 4, \cdot \prod_d 10, 11, 12, 13, 14, 15$

$Y_2 = \prod 0, 5, 6, 7, 8, \cdot \prod_d 10, 11, 12, 13, 14, 15$

$Y_1 = \prod 0, 3, 4, 7, 8 \cdot \prod_d 10, 11, 12, 13, 14, 15$

$Y_0 = \prod_m 0, 2, 4, 6, 8 \cdot \prod_d 10, 11, 12, 13, 14, 15$

SOP

$Y_3 = A + BD + BC$

$Y_2 = \bar{B}D + \bar{B}C + B\bar{C}\bar{D}$

$Y_1 = \bar{C}D + C\bar{D}$

$Y_0 = D$

POS

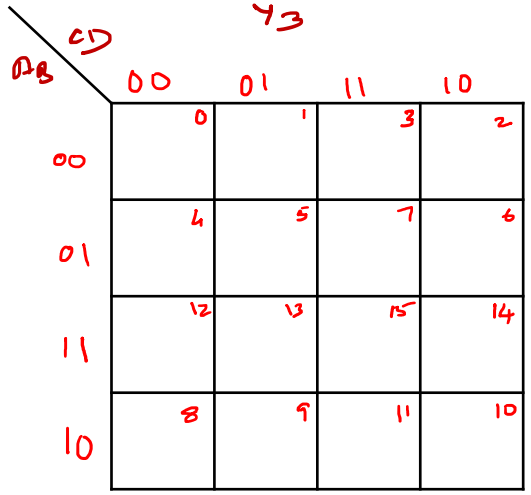
$Y_3 =$

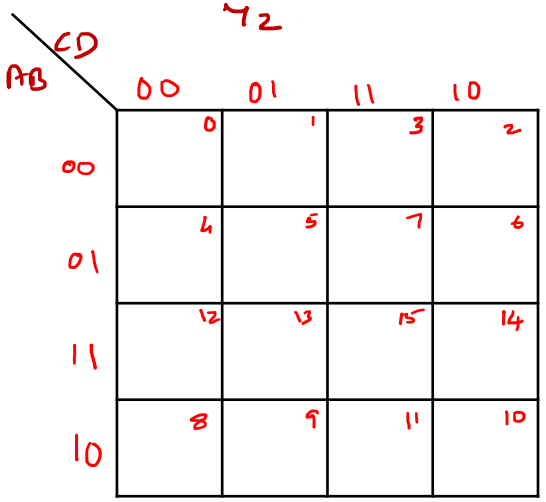
$Y_2 =$

$Y_1 =$

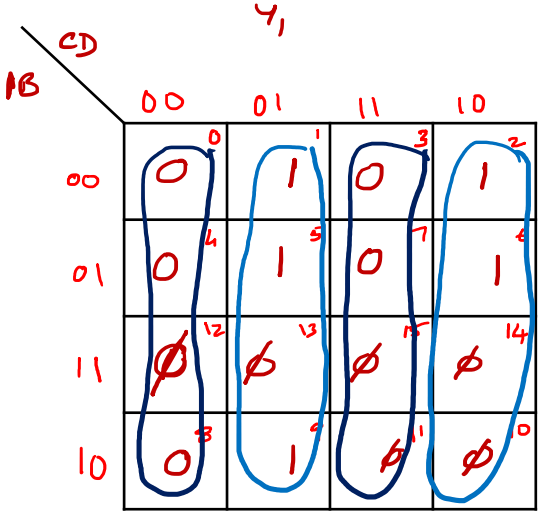
$Y_0 =$

Highlighted texts are invalid combinations at input





Note: Y_3 & Y_2 Expressions are same as that of previous Example

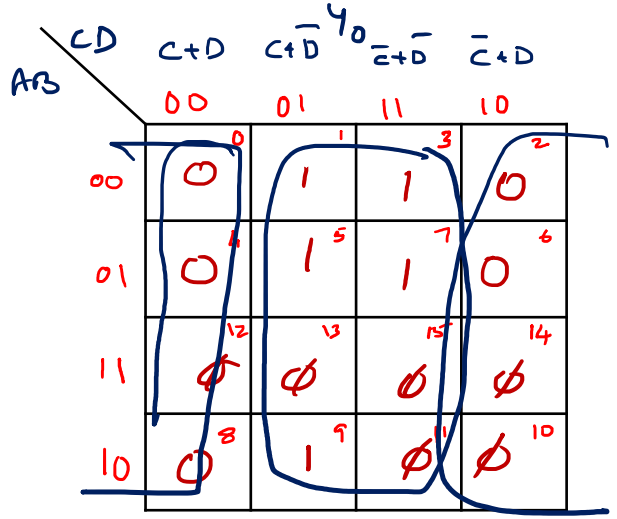


SOP

$Y_1 = \bar{C}D + C\bar{D}$

POS

$Y_1 = (C+D)(\bar{C}+\bar{D})$



SOP

$Y_0 = D$

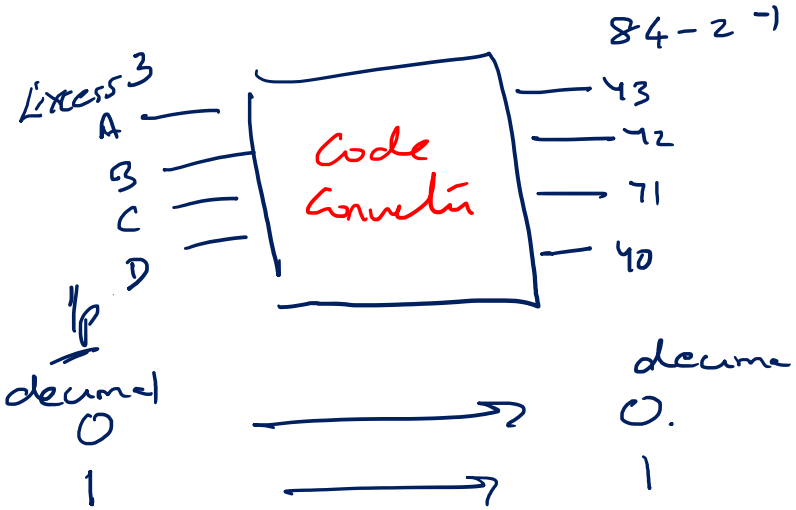
POS

$Y_0 = D$

Design a code converter to convert a decimal digit represented in Excess 3 code to a decimal digit represented in 8 4 -2 -1 code.

Decimal Digit	Excess 3 A B C D (i/p)	84-2-1 Y3 Y2 Y1 Y0 (o/p)
0	0 0 1 1 m3	0 0 0 0
1	0 1 0 0 m4	0 1 1 1
2	0 1 0 1 m5	0 1 1 0
3	0 1 1 0 m6	0 1 0 1
4	0 1 1 1 m7	0 1 0 0
5	1 0 0 0 m8	1 0 1 1
6	1 0 0 1 m9	1 0 1 0
7	1 0 1 0 m10	1 0 0 1
8	1 0 1 1 m11	1 0 0 0
9	1 1 0 0 m12	1 1 1 1
-	0 0 0 0 m0	-
-	0 0 0 1 m1	-
-	0 0 1 0 m2	-
-	1 1 0 1 m13	-
-	1 1 1 0 m14	-
-	1 1 1 1 m15	-

Min terms	Excess 3 A B C D (i/p)	84-2-1 Y3 Y2 Y1 Y0 (o/p)
m0	0 0 0 0	ϕ ϕ ϕ ϕ
m1	0 0 0 1	ϕ ϕ ϕ ϕ
m2	0 0 1 0	ϕ ϕ ϕ ϕ
m3	0 0 1 1	0 0 0 0
m4	0 1 0 0	0 1 1 1
m5	0 1 0 1	0 1 1 0
m6	0 1 1 0	0 1 0 1
m7	0 1 1 1	0 1 0 0
m8	1 0 0 0	1 0 1 1
m9	1 0 0 1	1 0 1 0
m10	1 0 1 0	1 0 0 1
m11	1 0 1 1	1 0 0 0
m12	1 1 0 0	1 1 1 1
m13	1 1 0 1	ϕ ϕ ϕ ϕ
m14	1 1 1 0	ϕ ϕ ϕ ϕ
m15	1 1 1 1	ϕ ϕ ϕ ϕ

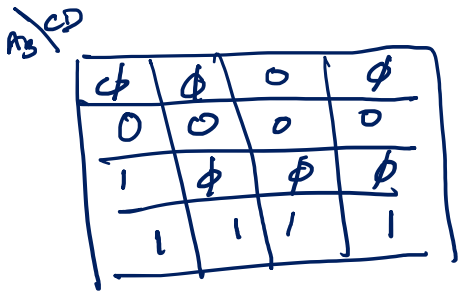


$Y_3 = \sum 8, 9, 10, 11, 12 + \sum d\ 0, 1, 2, 13, 14, 15$

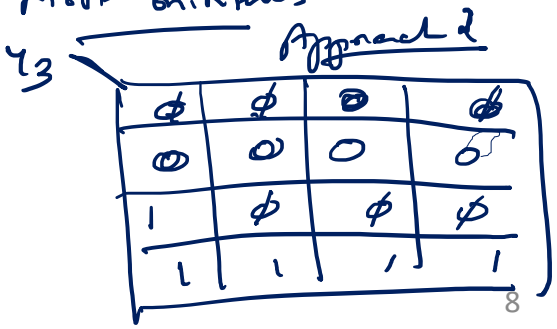
approach 2

- i/p is a 4-bit representation
- 4-bit → 16 combinations (no, no)
- last four minterms

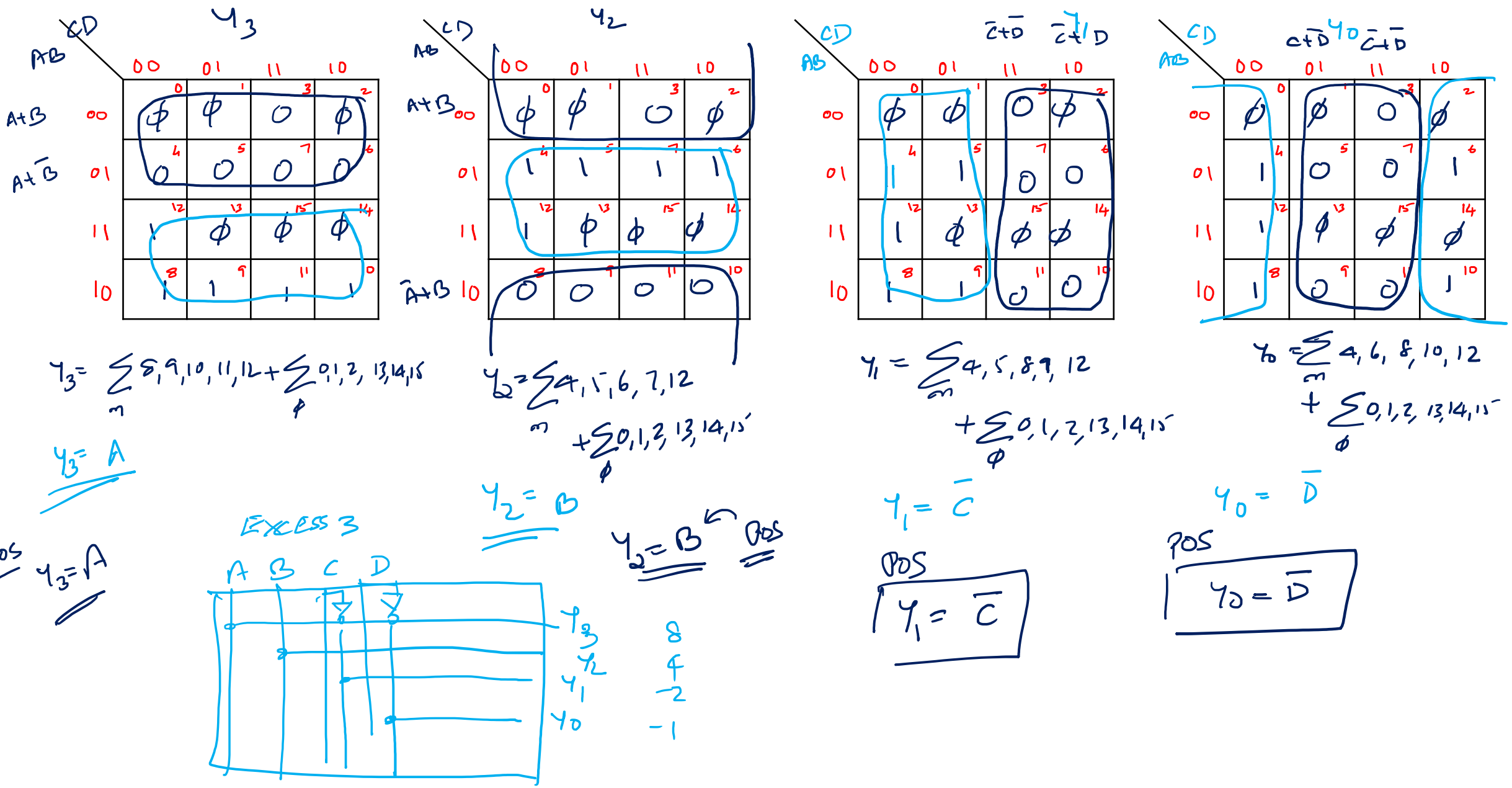
Y_3



Y_3 Approach 2



Highlighted texts are invalid combinations at input


Y_3
CD
AB
A+B
A+B̄
00 01 11 10
$Y_3 = \sum_m 8,9,10,11,12 + \sum_\phi 0,1,2,13,14,15$
$Y_3 = A$
POS
$Y_3 = A$
Y_2
$Y_2 = \sum_m 4,5,6,7,12 + \sum_\phi 0,1,2,13,14,15$
$Y_2 = B$
$Y_2 = B$ POS
Y_1
$\bar{C}+\bar{D}$ $\bar{C}+D$
$Y_1 = \sum_m 4,5,8,9,12 + \sum_\phi 0,1,2,13,14,15$
$Y_1 = \bar{C}$
POS
$Y_1 = \bar{C}$
Y_0
$C+\bar{D}$ $\bar{C}+\bar{D}$
$Y_0 = \sum_m 4,6,8,10,12 + \sum_\phi 0,1,2,13,14,15$
$Y_0 = \bar{D}$
POS
$Y_0 = \bar{D}$
EXCESS 3
A B C D
Y_3 Y_2 Y_1 Y_0
8 4 2 1

- Design a code converter to convert a decimal digit represented in 8 4 -2 -1 code to a decimal digit represented in 2 4 2 1 code.

Decimal digit	8 4 -2 -1 A B C D	2 4 2 1 Y3 Y2 Y1 Y0
0	0 0 0 0 m_0	0 0 0 0
1	0 1 1 1 m_7	0 0 0 1
2	0 1 1 0 m_6	0 0 1 0
3	0 1 0 1 m_5	0 0 1 1
4	0 1 0 0 m_4	0 1 0 0
5	1 0 1 1 m_{11}	1 0 ϕ ϕ
6	1 0 1 0 m_{10}	1 1 0 0
7	1 0 0 1 m_9	1 1 0 1
8	1 0 0 0 m_8	1 1 1 0
9	1 1 1 1 m_{15}	1 1 1 1
-	0 0 0 1 m_1	
-	0 0 1 0 m_2	
-	0 0 1 1 m_3	
-	1 1 0 0 m_{12}	
-	1 1 0 1 m_{13}	
-	1 1 1 0 m_{14}	

Min terms	8 4 -2 -1 A B C D	2 4 2 1 Y3 Y2 Y1 Y0
m0	0 0 0 0 0	0 0 0 0
m1	0 0 0 1 x	ϕ ϕ ϕ ϕ
m2	0 0 1 0 x	ϕ ϕ ϕ ϕ
m3	0 0 1 1 x	ϕ ϕ ϕ ϕ
m4	0 1 0 0 4	0 1 0 0
m5	0 1 0 1 5	0 0 1 1
m6	0 1 1 0 6	0 0 1 0
m7	0 1 1 1 7	0 0 0 1
m8	1 0 0 0 8	1 1 1 0
m9	1 0 0 1 9	1 1 0 1
m10	1 0 1 0 x	1 1 ϕ ϕ
m11	1 0 1 1 x	1 0 1 1
m12	1 1 0 0 x	ϕ ϕ ϕ ϕ
m13	1 1 0 1 x	ϕ ϕ ϕ ϕ
m14	1 1 1 0 x	ϕ ϕ ϕ ϕ
m15	1 1 1 1 9	1 1 1 1

$\phi = \sum 1, 2, 3, 12, 13, 14$

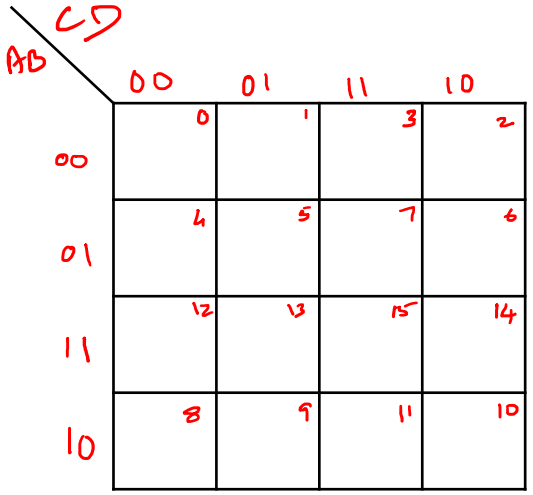
$Y_3 = \sum 8, 9, 10, 11, 15 + \sum_{\phi} 1, 2, 3, 12, 13, 14$

$Y_3 = \sum 11, 10, 9, 8, 15 + \sum_{\phi} 1, 2, 3, 12, 13, 14$

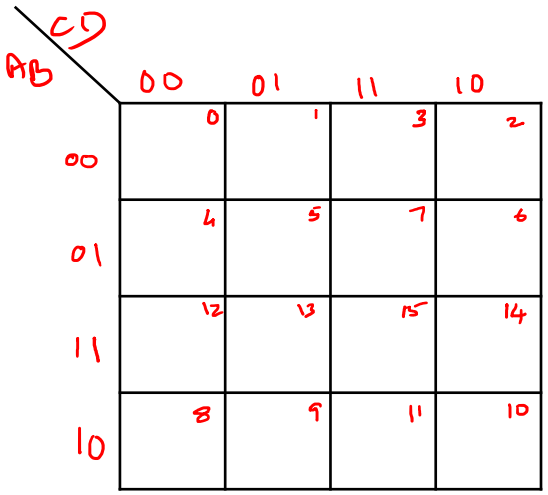
Solve for Y_3, Y_2, Y_1, Y_0 Home Work

& Realize using Basic Gates

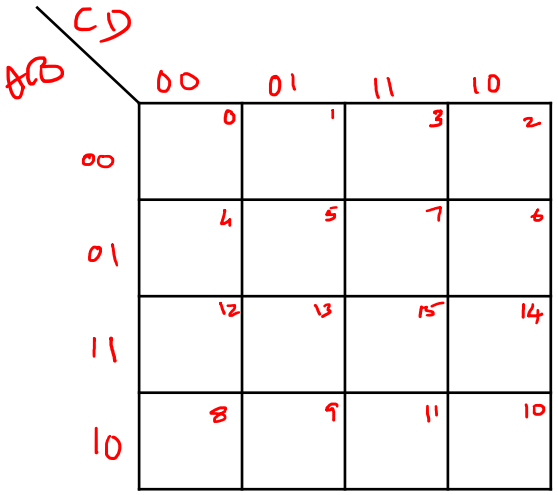
Highlighted texts are invalid combinations at input



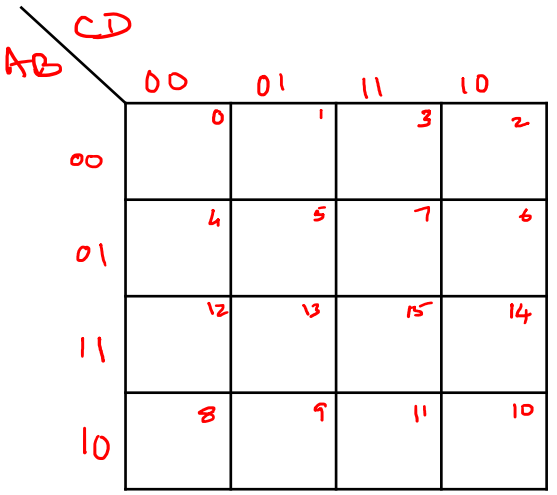
Y_3



Y_2



Y_1



Y_0

Solve for

SOP

$Y_3 =$

$Y_2 =$

$Y_1 =$

$Y_0 =$

POS

$Y_3 =$

$Y_2 =$

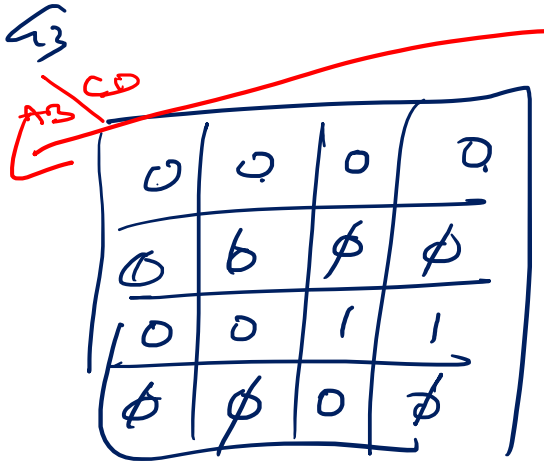
$Y_1 =$

$Y_0 =$

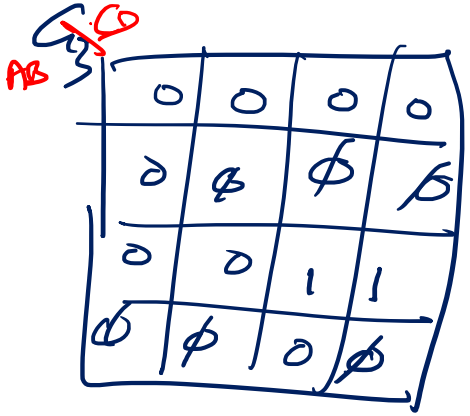
- Design a code converter to convert a decimal digit represented in 2 4 2 1 code to a decimal digit represented in gray code.

Decimal digit	2 4 2 1 A B C D	Gray Code G3 G2 G1 G0
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
-		
-		
-		
-		
-		
-		

Min terms	2 4 2 1 A B C D	Gray Code G3 G2 G1 G0
m0		
m1		
m2		
m3		
m4		
m5		
m6		
m7		
m8		
m9		
m10		
m11		
m12		
m13		
m14		
m15		



approach 2
reading from truth table



approach 1
reading from the truth table

Any approach can be used.

G_3

AB \ CD	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

G_2

AB \ CD	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

G_1

AB \ CD	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

G_0

AB \ CD	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

Solve for G_3, G_2, G_1, G_0

SOP

G_3

G_2

G_1

G_0

POS

G_3

G_2

G_1

G_0