

Paper 7, TDC Part-3
Chapter– 4, Combinational Logic Design
Lecture - 22

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Combinational Logic Design

Let us now obtain logical expression for B_2 , B_1 & B_0

A handwritten Karnaugh Map (K-Map) for the output B_2 of a 4-bit adder. The map is a 4x4 grid with inputs G_3, G_2 on the vertical axis and G_1, G_0 on the horizontal axis. The vertical axis labels are 00, 01, 11, 10. The horizontal axis labels are 00, 01, 11, 10. The map contains ones in the following cells: (01, 00), (01, 01), (01, 11), (01, 10), (10, 00), (10, 01), (10, 11), (10, 10). Two groups of four ones are circled in blue: one group covers the middle two rows (01 and 10) across all columns, and another group covers the bottom two rows (11 and 10) across all columns. A note 'Offset Adjacencies' with arrows points to the vertical relationship between the two groups. The text to the right explains that these are offset adjacent groups of four ones, and the expression for B_2 can be expressed using EX-OR or ~~EX-NOT~~ operations.

$G_3 \backslash G_2 / G_1, G_0$	00	01	11	10
00				
01	1	1	1	1
11				
10	1	1	1	1

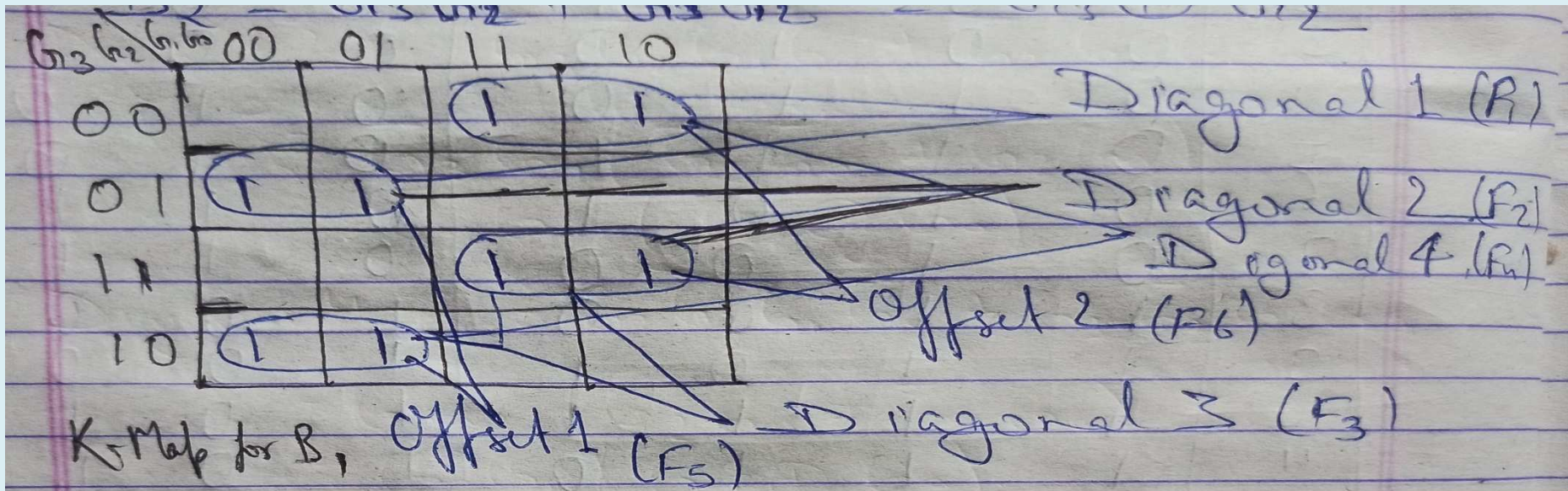
K-Map for B_2

Offset Adjacencies

Here there is 2 group of ones with 4 ones in each group. These 2 groups are in offset adjacentness so the expression for B_2 can be expressed by EX-OR / ~~EX-NOT~~ operation.

$$B_2 = \overline{G_3} G_2 + G_3 \overline{G_2} = G_3 \oplus G_2$$

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$$\text{Diagonal 1; } F_1 = \overline{G_3} \overline{G_2} G_1 + \overline{G_3} G_2 \overline{G_1} = \overline{G_3} (\overline{G_2} G_1 + G_2 \overline{G_1}) = \overline{G_3} (G_2 \oplus G_1)$$

$$\text{Diagonal 2; } F_2 = \overline{G_3} G_2 \overline{G_1} + G_3 G_2 G_1 = G_2 (\overline{G_3} \overline{G_1} + G_3 G_1) = G_2 (G_3 \odot G_1)$$

$$\text{Diagonal 3; } F_3 = G_3 G_2 G_1 + \overline{G_3} G_2 \overline{G_1} = G_2 (G_3 G_1 + \overline{G_3} \overline{G_1}) = G_2 (G_3 \odot G_1)$$

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$$\text{Diagonal 4, } F_4 = \overline{G_3} \overline{G_2} G_1 + G_3 G_2 G_1$$

$$= \overline{G_2} (\overline{G_3} G_1 + G_3 G_1)$$

$$= \overline{G_2} (G_3 \oplus G_1)$$

$$\text{Offset 1, } F_5 = \overline{G_3} G_2 \overline{G_1} + G_3 \overline{G_2} \overline{G_1} = \overline{G_1} (\overline{G_3} G_2 + G_3 \overline{G_2})$$
$$= \overline{G_1} (G_3 \oplus G_2)$$

$$\text{Offset 2, } F_6 = \overline{G_3} \overline{G_2} G_1 + G_3 G_2 G_1 = G_1 (\overline{G_3} \overline{G_2} + G_3 G_2)$$
$$= G_1 (G_3 \odot G_2)$$

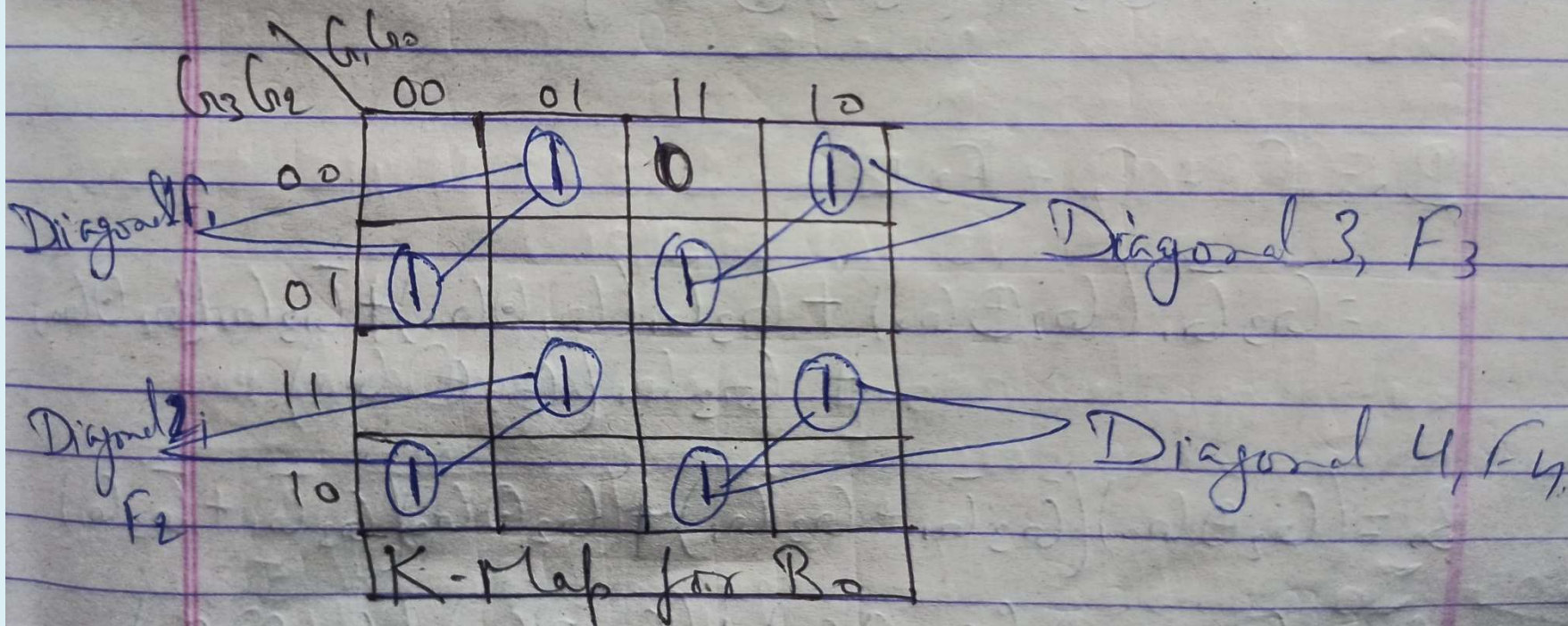
Now the expression for B_3 can be written by considering either (Diagonal 1 & Diagonal 3) or (Diagonal 2 & Diagonal 4) or (Offset 1, Offset 2).

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$$B_1 = \text{Diagonal 2 (F}_2\text{)} + \text{Diagonal 4 (F}_4\text{)}$$

$$B_1 = G_2 (G_3 \odot G_4) + \overline{G_2} (G_3 \oplus G_1)$$

$$B_1 = G_2 \oplus G_3 \oplus G_1$$



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$$\text{Diagonal 1, } F_1 = \bar{A}_3 \bar{A}_2 \bar{A}_1 A_0 + \bar{A}_3 A_2 \bar{A}_1 \bar{A}_0$$

$$= \bar{A}_3 \bar{A}_1 (\bar{A}_2 A_0 + A_2 \bar{A}_0) = \bar{A}_3 \bar{A}_1 (\bar{A}_2 A_0 + A_2 \bar{A}_0)$$

$$= \bar{A}_3 \bar{A}_1 (A_2 \oplus A_0)$$

$$\text{Diagonal 2, } F_2 = A_3 A_2 \bar{A}_1 A_0 + A_3 \bar{A}_2 \bar{A}_1 \bar{A}_0$$

$$= A_3 \bar{A}_1 (A_2 A_0 + \bar{A}_2 \bar{A}_0) = A_3 \bar{A}_1 (A_2 \odot A_0)$$

$$\text{Diagonal 3, } F_3 = \bar{A}_3 \bar{A}_2 A_1 \bar{A}_0 + \bar{A}_3 A_2 A_1 A_0$$

$$= \bar{A}_3 A_1 (\bar{A}_2 \bar{A}_0 + A_2 A_0)$$

$$= \bar{A}_3 A_1 (A_2 \odot A_0)$$

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$$\begin{aligned} \text{Diagonal 4, } F_4 &= G_3 G_2 G_1 \bar{G}_0 + G_3 \bar{G}_2 G_1 G_0 \\ &= G_3 G_1 (G_2 \bar{G}_0 + \bar{G}_2 G_0) \\ &= G_3 G_1 (G_2 \oplus G_0) \end{aligned}$$

$$B_0 = F_1 + F_2 + F_3 + F_4$$

$$\begin{aligned} &= \bar{G}_3 \bar{G}_1 (G_2 \oplus G_0) + G_3 \bar{G}_1 (G_2 \odot G_0) + \bar{G}_3 G_1 (G_2 \odot G_0) \\ &\quad + G_3 G_1 (G_2 \oplus G_0) \end{aligned}$$

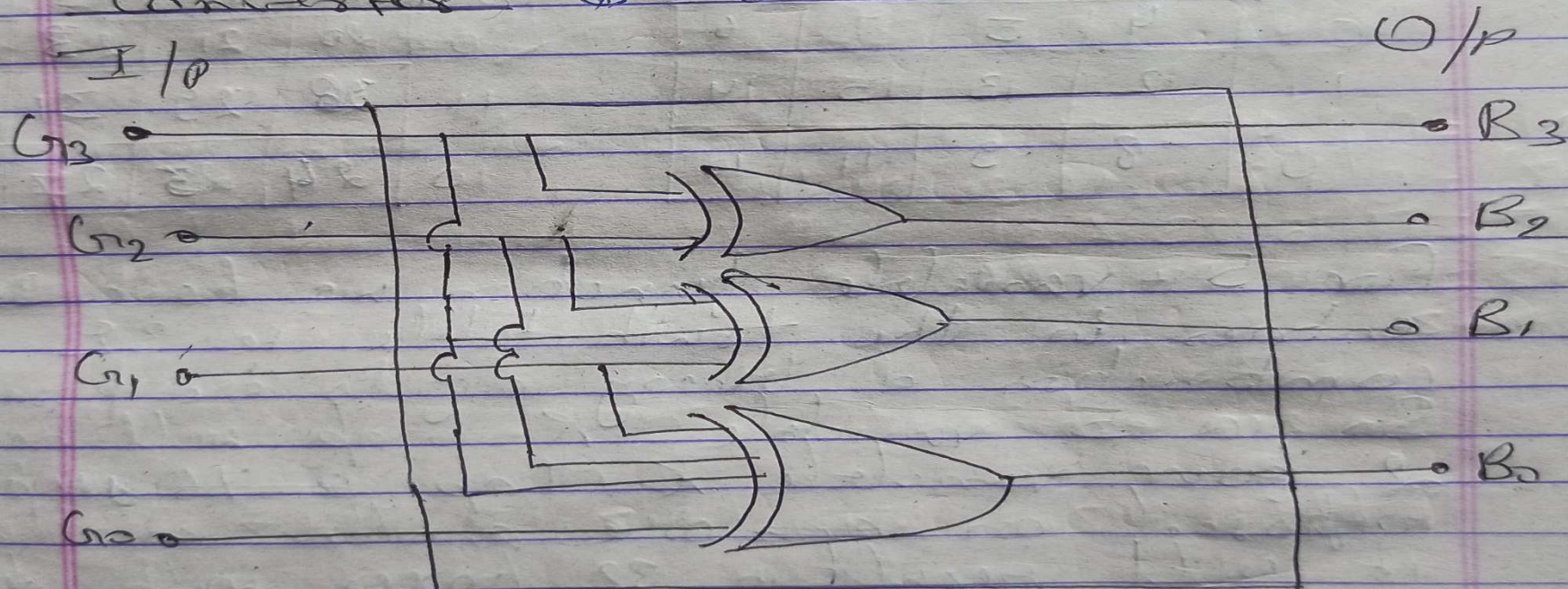
$$B_0 = (G_2 \oplus G_0) (\bar{G}_3 \bar{G}_1 + G_3 G_1) + (G_2 \odot G_0) (G_3 \bar{G}_1 + \bar{G}_3 G_1)$$

$$B_0 = (G_2 \oplus G_0) (G_3 \odot G_1) + (G_2 \odot G_0) (G_3 \oplus G_1)$$

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$$B_0 = (G_2 \oplus G_0)(G_3 \oplus G_1) + (G_2 \oplus G_0)(G_3 \oplus G_1)$$
$$= (G_2 \oplus G_0) \oplus (G_3 \oplus G_1) = G_3 \oplus G_2 \oplus G_1 \oplus G_0$$

Ckt Diagram for Gray to Binary Code Converter is shown below



4-bit Gray to Binary code converter

Combinational Logic Design

Refer book- Modern Digital Electronics by RP Jain.

Thank You