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CT-032

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Question No 1:

Construct a combinational circuit with three inputs x, y and z and three outputs A, B, and C. When the binary input is 0, 1, 2 and 3; the binary output is one greater than the input. When the binary input is 4, 5, 6 or 7, the binary output is two less than the input.

x	y	z	A	B	C
0	0	0	0	0	1
0	0	1	0	1	0
0	1	0	0	1	1
0	1	1	1	0	0
1	0	0	0	1	0
1	0	1	0	1	1
1	1	0	1	0	0
1	1	1	1	0	1

A

xy \ z	0	1
00		
01		1
11	1	1
10		

B

xy \ z	0	1
00		1
01	1	
11		
10	1	1

C

xy \ z	0	1
00	1	
01	1	
11		1
10		1

$A = xy + yz$

$B = \bar{x}y\bar{z} + \bar{y}z + x\bar{y}$

$C = \bar{x}\bar{z} + xz$

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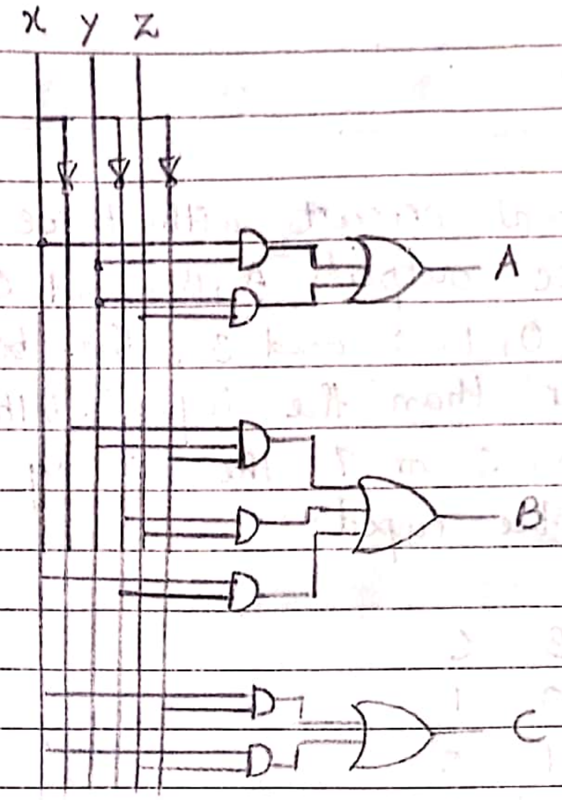

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Question Number 2:

Construct a full-subtractor circuit with three inputs x, y, Bin and two outputs Diff and Bout. The circuit subtracts x - y - Bin, where Bin is the input borrow, Bout is the output borrow, and Diff is the difference.

x	y	Bin	Diff	Bout
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	0	1
1	0	0	1	0
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

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Diff

xy \ Bin	0	1
00		1
01	1	
11		1
10	1	

$Diff = \bar{x}\bar{y}B_{in} + \bar{x}y\overline{B_{in}} + xyB_{in} + x\bar{y}\overline{B_{in}}$

$Diff = \bar{x}(\bar{y}B_{in} + y\overline{B_{in}}) + x(yB_{in} + \bar{y}\overline{B_{in}})$

$Diff = \bar{x}(y \oplus B_{in}) + x(\overline{y \oplus B_{in}})$

$\boxed{Diff = x \oplus (y \oplus B_{in})}$

Bout

xy \ Bin	0	1
00		1
01	1	1
11		1
10		

From K-map:

$B_{out} = \bar{x}\bar{y}B_{in} + \bar{x}y + yB_{in}$

$\boxed{B_{out} = \bar{x}y + B_{in}(\bar{x} + y)}$

~~Without~~ From Truth Table:

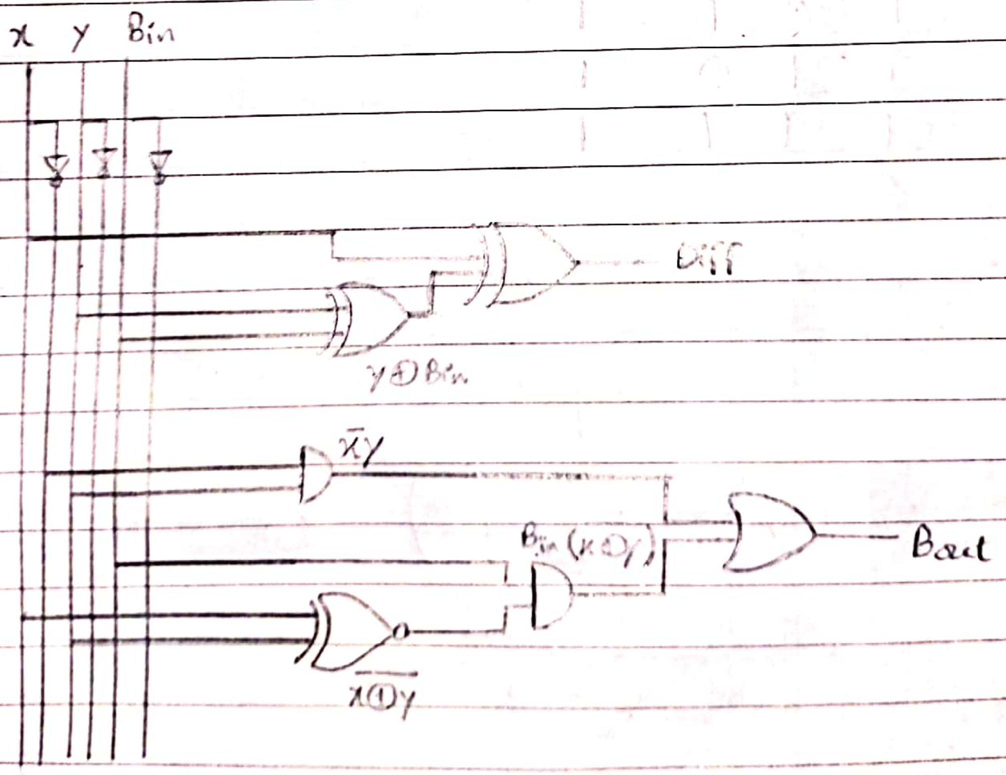
$B_{out} = \bar{x}\bar{y}B_{in} + \bar{x}y\overline{B_{in}} + \bar{x}yB_{in} + xyB_{in}$

$B_{out} = \overline{xy}B_{in} + xyB_{in} + \bar{x}yB_{in} + \bar{x}y\overline{B_{in}}$

$B_{out} = B_{in}(\overline{xy} + xy) + \bar{x}y(B_{in} + \overline{B_{in}})$

$B_{out} = B_{in}(\overline{x \oplus y}) + \bar{x}y(1)$

$\boxed{B_{out} = \bar{x}y + B_{in}(\overline{x \oplus y})}$



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Question Number 3:

A committee of three individuals decides issues for an organization. Each individual votes either yes or no for each proposal that arises. A proposal is passed if it receives at least two yes votes. Construct a circuit that determines whether a proposal passes.

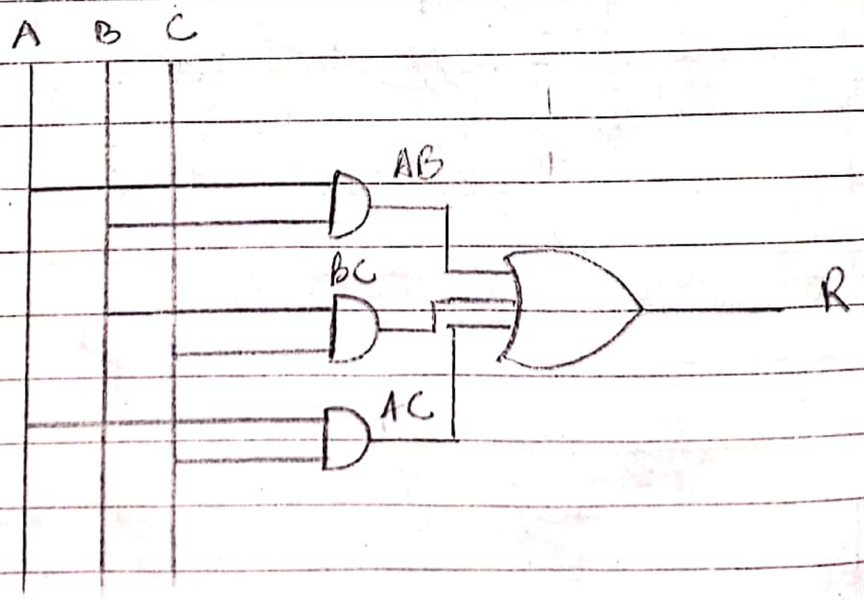
A 1 ⇒ Yes

0 ⇒ NO

A	B	C	R
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

R: AB \ C	0	1
00		
01		1
11	1	1
10		1

$R = AB + BC + AC$



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Question Number 4:

Construct a BCD-to-decimal decoder using the unused combinations of the BCD code as don't-care conditions.

A	B	C	D	D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9
0	0	0	0	1	0	0	0	0	0	0	0	0	0
0	0	0	1	0	1	0	0	0	0	0	0	0	0
0	0	1	0	0	0	1	0	0	0	0	0	0	0
0	0	1	1	0	0	0	1	0	0	0	0	0	0
0	1	0	0	0	0	0	0	1	0	0	0	0	0
0	1	0	1	0	0	0	0	0	1	0	0	0	0
0	1	1	0	0	0	0	0	0	0	1	0	0	0
0	1	1	1	0	0	0	0	0	0	0	1	0	0
1	0	0	0	0	0	0	0	0	0	0	0	1	0
1	0	0	1	0	0	0	0	0	0	0	0	0	1

Abbreviated Truth Table:

A	B	C	D	Outputs (0)
0	0	0	0	D_0
0	0	0	1	D_1
0	0	1	0	D_2
0	0	1	1	D_3
0	1	0	0	D_4
0	1	0	1	D_5
0	1	1	0	D_6
0	1	1	1	D_7
1	0	0	0	D_8
1	0	0	1	D_9

o

AB \ CD	00	01	11	10
00	D_0	D_1	D_3	D_2
01	D_4	D_5	D_7	D_6
11	X	X	X	X
10	D_8	D_9	X	X

$D_0 = \overline{A}\,\overline{B}\,\overline{C}\,\overline{D}$, $D_6 = BC\overline{D}$

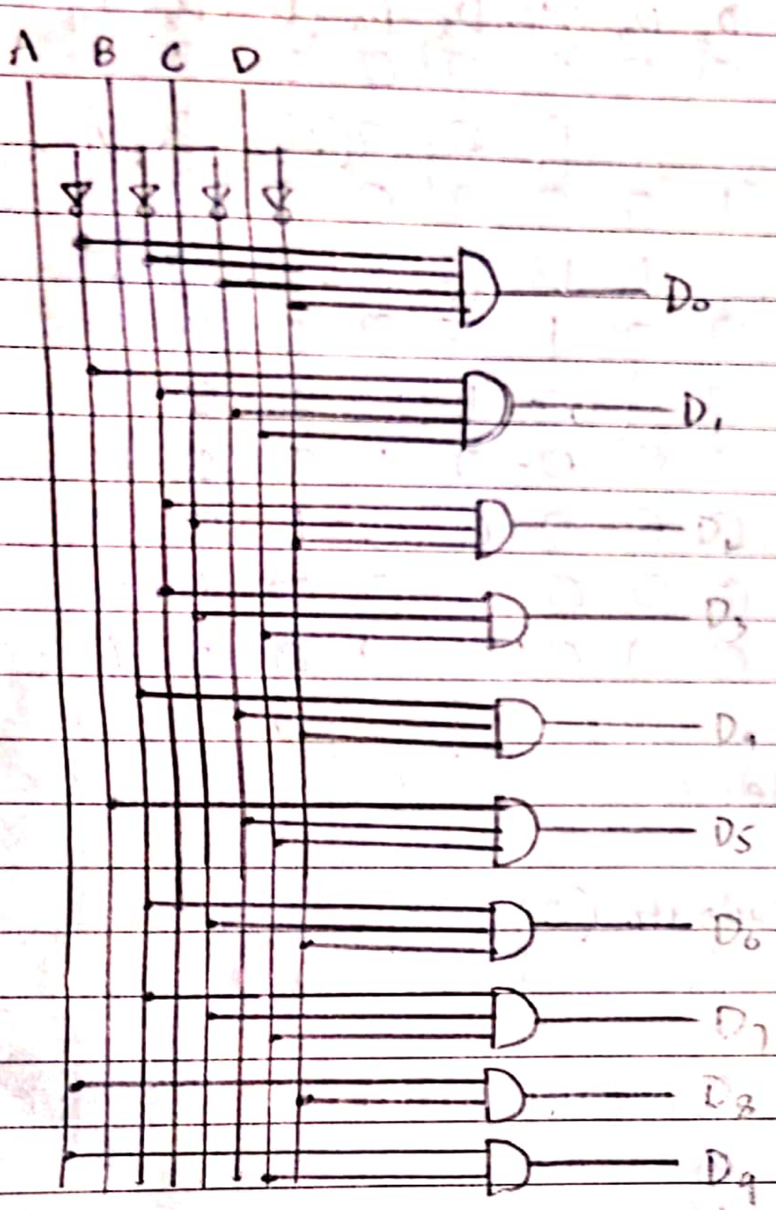
$D_1 = \overline{A}\,\overline{B}\,\overline{C}D$, $D_7 = BCD$

$D_2 = \overline{B}C\overline{D}$, $D_8 = A\overline{D}$

$D_3 = \overline{B}CD$, $D_9 = AD$

$D_4 = B\overline{C}\,\overline{D}$

$D_5 = B\overline{C}D$



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Question Number 5:

Construct a 5-bit parity system.

Parity Generator:

A	B	C	D	P_{odd}	P_{even}
0	0	0	0	1	0
0	0	0	1	0	1
0	0	1	0	0	1
0	0	1	1	1	0
0	1	0	0	0	1
0	1	0	1	1	0
0	1	1	0	1	0
0	1	1	1	0	1
1	0	0	0	0	1
1	0	0	1	1	0
1	0	1	0	1	0
1	0	1	1	0	1
1	1	0	0	1	0
1	1	0	1	0	1
1	1	1	0	0	1
1	1	1	1	1	0

P_{odd}

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

P_{even}

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

P_{odd}:

$$P_{odd} = \bar A\bar B\bar C\bar D + \bar A\bar B CD + \bar A B\bar C D + \bar A B C\bar D + AB\bar C\bar D + ABCD + A\bar B\bar C D + A\bar B C\bar D$$

$$P_{odd} = \bar A\bar B(\bar C\bar D + CD) + \bar A B(\bar C D + C\bar D) + AB(\bar C\bar D + CD) + A\bar B(\bar C D + C\bar D)$$

$$P_{odd} = \bar A\bar B(\overline{C\oplus D}) + \bar A B(C\oplus D) + AB(\overline{C\oplus D}) + A\bar B(C\oplus D)$$

$$P_{odd} = \bar A\left[\bar B(\overline{C\oplus D}) + B(C\oplus D)\right] + A\left[B(\overline{C\oplus D}) + \bar B(C\oplus D)\right]$$

$$P_{odd} = \bar A(\overline{B\oplus C\oplus D}) + A(B\oplus C\oplus D)$$

$$\boxed{P_{odd} = A \odot (B\oplus C\oplus D)}$$

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P_{even}:

$$P_{even} = \bar A\bar B\bar C D + \bar A\bar B C\bar D + \bar A B\bar C\bar D + \bar A BCD + AB\bar C D + ABC\bar D + A\bar B\bar C\bar D + A\bar B CD$$

$$P_{even} = \bar A\bar B(\bar C D + C\bar D) + \bar A B(\bar C\bar D + CD) + AB(\bar C D + C\bar D) + A\bar B(\bar C\bar D + CD)$$

$$P_{even} = \bar A\bar B(C\oplus D) + \bar A B(\overline{C\oplus D}) + AB(C\oplus D) + A\bar B(\overline{C\oplus D})$$

$$P_{even} = \bar A[\bar B(C\oplus D) + B(\overline{C\oplus D})] + A[B(C\oplus D) + \bar B(\overline{C\oplus D})]$$

$$P_{even} = \bar A(B\oplus C\oplus D) + A(\overline{B\oplus C\oplus D})$$

$$\boxed{P_{even} = A\oplus(B\oplus C\oplus D)}$$

Parity Checker:

Pe/Po	A	B	C	D	Codd	Ceven
0	0	0	0	0	1	0
0	0	0	0	1	0	1
0	0	0	1	0	0	1
0	0	0	1	1	1	0
0	0	1	0	0	0	1
0	0	1	0	1	1	0
0	0	1	1	0	1	0
0	0	1	1	1	0	1
0	1	0	0	0	0	1
0	1	0	0	1	1	0
0	1	0	1	0	1	0
0	1	0	1	1	0	1
0	1	1	0	0	1	0
0	1	1	0	1	0	1
0	1	1	1	0	0	1

Pe/Po	A	B	C	D	Codd	Ceven
0	1	1	1	1	1	0
1	0	0	0	0	0	1
1	0	0	0	1	1	0
1	0	0	1	0	1	0
1	0	0	1	1	0	1
1	0	1	0	0	1	0
1	0	1	0	1	0	1
1	0	1	1	0	0	1
1	0	1	1	1	1	0
1	1	0	0	0	1	0
1	1	0	0	1	0	1
1	1	0	1	0	0	1
1	1	0	1	1	1	0
1	1	1	0	0	0	1
1	1	1	0	1	1	0
1	1	1	1	0	1	0
1	1	1	1	1	0	1

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C_{odd}

$P_0A \backslash BCD$	000	001	011	010	110	111	101	100
00	1		1		1		1	
01		1		1		1		1
11	1		1		1		1	
10		1		1		1		1

$$C_{odd} = \overline{P_0}\,\overline{A}\,\overline{B}\,\overline{C}\,\overline{D} + \overline{P_0}\,\overline{A}\,\overline{B}CD + \overline{P_0}\,\overline{A}BC\overline{D} + \overline{P_0}\,\overline{A}B\overline{C}D + \overline{P_0}A\overline{B}\,\overline{C}D + \overline{P_0}A\overline{B}C\overline{D} + \overline{P_0}ABCD +$$
$$\overline{P_0}AB\overline{C}\,\overline{D} + P_0A\overline{B}\,\overline{C}\,\overline{D} + P_0A\overline{B}CD + P_0ABC\overline{D} + P_0AB\overline{C}D + P_0\overline{A}\,\overline{B}\,\overline{C}D + P_0\overline{A}\,\overline{B}C\overline{D} +$$
$$P_0\overline{A}BCD + P_0\overline{A}B\overline{C}\,\overline{D}.$$

$$C_{odd} = \overline{P_0}\left(\overline{A}\,\overline{B}\,\overline{C}\,\overline{D} + \overline{A}\,\overline{B}CD + \overline{A}BC\overline{D} + \overline{A}B\overline{C}D + A\overline{B}\,\overline{C}D + A\overline{B}C\overline{D} + ABCD + AB\overline{C}\,\overline{D}\right)$$
$$+ P_0\left(A\overline{B}\,\overline{C}\,\overline{D} + A\overline{B}CD + ABC\overline{D} + AB\overline{C}D + \overline{A}\,\overline{B}\,\overline{C}D + \overline{A}\,\overline{B}C\overline{D} + \overline{A}BCD + \overline{A}B\overline{C}\,\overline{D}\right)$$

$$C_{odd} = \overline{P_0}\left[\overline{A}\{\overline{B}(\overline{C}\,\overline{D} + CD) + B(C\overline{D} + \overline{C}D)\} + A\{\overline{B}(\overline{C}D + C\overline{D}) + B(CD + \overline{C}\,\overline{D})\}\right]$$
$$+ P_0\left[A\{\overline{B}(\overline{C}\,\overline{D} + CD) + B(C\overline{D} + \overline{C}D)\} + \overline{A}\{\overline{B}(\overline{C}D + C\overline{D}) + B(CD + \overline{C}\,\overline{D})\}\right]$$

$$= \overline{P_0}\left[\overline{A}\{\overline{B}(\overline{C \oplus D}) + B(C \oplus D)\} + A\{\overline{B}(C \oplus D) + B(\overline{C \oplus D})\}\right] +$$
$$P_0\left[A\{\overline{B}(\overline{C \oplus D}) + B(C \oplus D)\} + \overline{A}\{\overline{B}(C \oplus D) + B(\overline{C \oplus D})\}\right]$$

$$C_{odd} = \overline{P_0}\left[\overline{A}\{\overline{B \oplus (C \oplus D)}\} + A\{B \oplus (C \oplus D)\}\right] + P_0\left[A\{\overline{B \oplus (C \oplus D)}\}\right.$$
$$\left. + \overline{A}\{B \oplus (C \oplus D)\}\right].$$

$$C_{odd} = \overline{P_0}\left[\overline{A \oplus \{B \oplus (C \oplus D)\}}\right] + P_0\left[A \oplus \{B \oplus (C \oplus D)\}\right].$$

$$\boxed{C_{odd} = P_0 \odot (A \oplus B \oplus C \oplus D).}$$

$$C_{even} = \overline{P_e}\,\overline{A}\,\overline{B}\,\overline{C}D + \overline{P_e}\,\overline{A}\,\overline{B}C\overline{D} + \overline{P_e}\,\overline{A}BCD + \overline{P_e}\,\overline{A}B\overline{C}\,\overline{D} + \overline{P_e}A\overline{B}\,\overline{C}\,\overline{D} + \overline{P_e}A\overline{B}CD + \overline{P_e}ABC\overline{D}$$
$$+ \overline{P_e}AB\overline{C}D + P_eA\overline{B}\,\overline{C}D + P_eA\overline{B}C\overline{D} + P_eAB\overline{C}\,\overline{D} + P_e\overline{A}\,\overline{B}\,\overline{C}\,\overline{D} + P_e\overline{A}\,\overline{B}CD + P_e\overline{A}BC\overline{D}$$
$$+ P_eABCD + P_e\overline{A}B\overline{C}D.$$

$$C_{even} = \overline{P_e}\left(\overline{A}\,\overline{B}\,\overline{C}D + \overline{A}\,\overline{B}C\overline{D} + \overline{A}BCD + \overline{A}B\overline{C}\,\overline{D} + A\overline{B}\,\overline{C}\,\overline{D} + A\overline{B}CD + ABC\overline{D} + AB\overline{C}D\right)$$
$$+ P_e\left(A\overline{B}\,\overline{C}D + A\overline{B}C\overline{D} + ABCD + AB\overline{C}\,\overline{D} + \overline{A}\,\overline{B}\,\overline{C}\,\overline{D} + \overline{A}\,\overline{B}CD + \overline{A}BC\overline{D}\right.$$
$$\left. + \overline{A}B\overline{C}D\right)$$

$$C_{even} = \overline{P_e}\left[\bar{A}\left\{\bar{B}\left(\bar{C}D + C\bar{D}\right) + B\left(CD + \bar{C}\bar{D}\right)\right\} + A\left\{\bar{B}\left(\bar{C}\bar{D} + CD\right) + B\left(C\bar{D} + \bar{C}D\right)\right\}\right] + P_e\left[A\left\{\bar{B}\left(\bar{C}D + C\bar{D}\right) + B\left(CD + \bar{C}\bar{D}\right)\right\} + A\left\{\bar{B}\left(\bar{C}\bar{D} + CD\right) + B\left(C\bar{D} + \bar{C}D\right)\right\}\right].$$

$$= \overline{P_e}\left[\bar{A}\left\{\bar{B}\left(C \oplus D\right) + B\left(\overline{C \oplus D}\right)\right\} + A\left\{\bar{B}\left(\overline{C \oplus D}\right) + B\left(C \oplus D\right)\right\}\right] + P_e\left[A\left\{\bar{B}\left(C \oplus D\right) + B\left(\overline{C \oplus D}\right)\right\} + \bar{A}\left\{\bar{B}\left(\overline{C \oplus D}\right) + B\left(C \oplus D\right)\right\}\right].$$

$$= \overline{P_e}\left[\bar{A}\left\{B \oplus \left(C \oplus D\right)\right\} + A\,\overline{\left\{B \oplus \left(C \oplus D\right)\right\}}\right] + P_e\left[A\left\{B \oplus \left(C \oplus D\right)\right\} + \bar{A}\,\overline{\left\{B \oplus \left(C \oplus D\right)\right\}}\right]$$

$$= \overline{P_e}\left[A \oplus \left\{B \oplus \left(C \oplus D\right)\right\}\right] + P_e\left[\overline{A \oplus \left\{B \oplus \left(C \oplus D\right)\right\}}\right]$$

$$\boxed{C_{even} = P_e \oplus \left(A \oplus B \oplus C \oplus D\right)}$$

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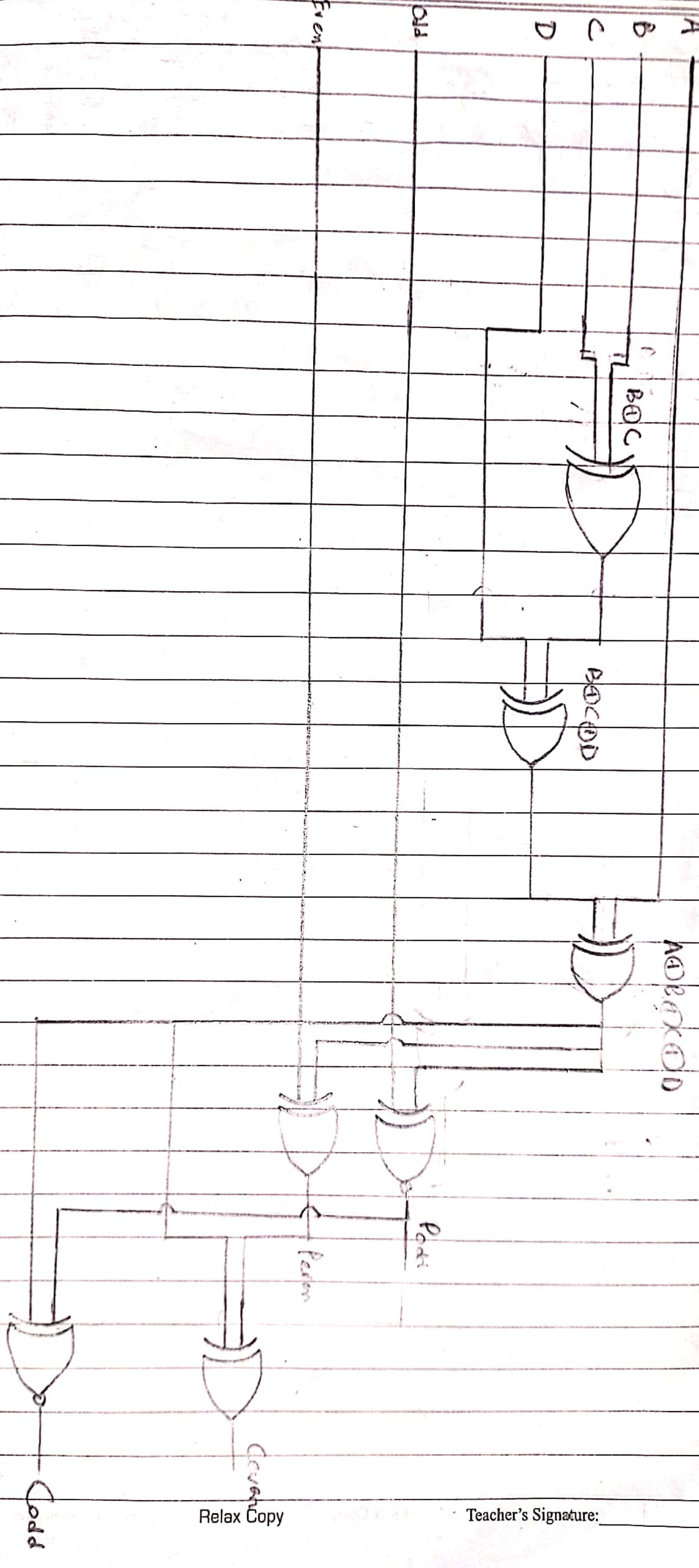

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