CE232 DIGITAL SYSTEM

Topic 7. Combinational Logic Circuit

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Subtopic

7.1 Combinational Circuits

7.2 Implementation Procedures

7.3 Adder

7.4 Subtractor

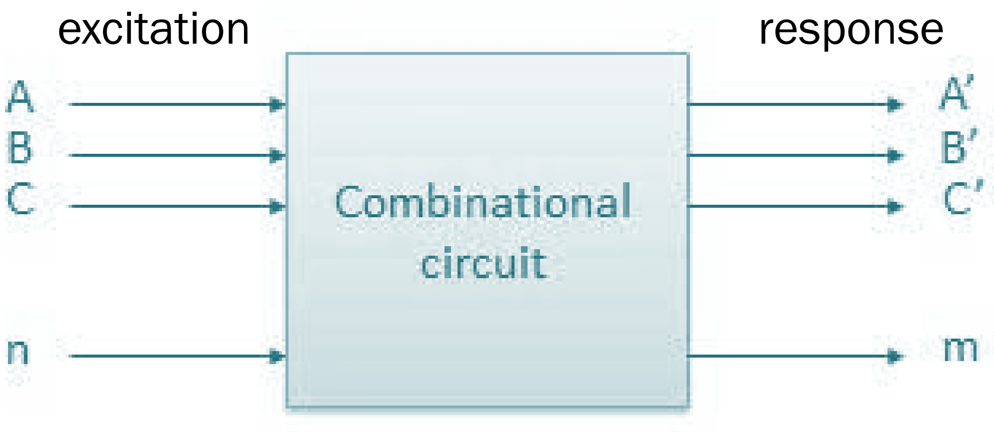
7.5 Code Conversion

7.1 Combinational Circuits

7.1 Combinational Circuits

Intro to Combinational Circuits

- A circuits which output is dependent upon combination of input variables
- The circuits **does not use any memory**
- It can have n number of inputs and m number of outputs



7.1 Combinational Circuits

Example of Combinational circuits

- Adders and subtractors
- Decoders
- MUX
- Code Inverters
- Comparators
- Read Only Memory, Programmable Logic Array, Programmable Array Logic

7.2 Implementation Procedures

7.2 Implementation Procedures

Procedures

- Observe the problem definition
- Determine the required input and output variables
- Assign letters symbols to the input variables
- Make truth table that defines required relationship
- Determine the simplified Boolean expression using K-MAP
- Draw Logic Diagram

7.2 Implementation Procedures

Example.

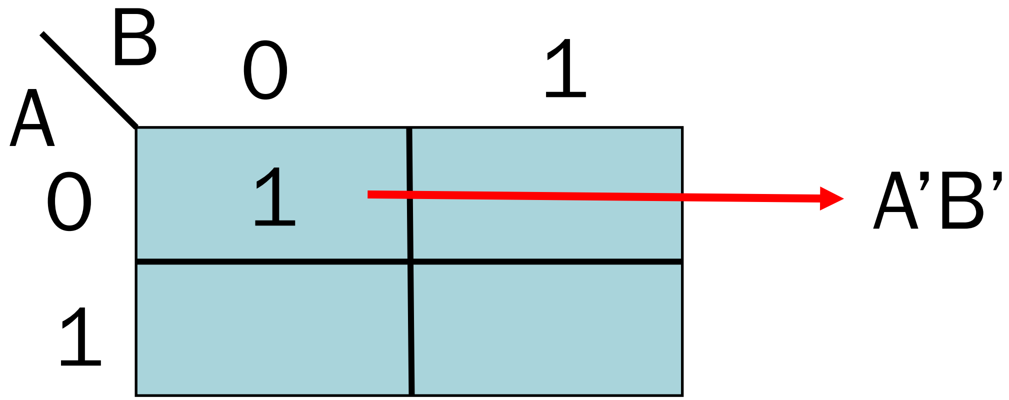
Design a combinational circuits with two input which produce output as logic 0 when any one input is 1

Inputs A, B output Y

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

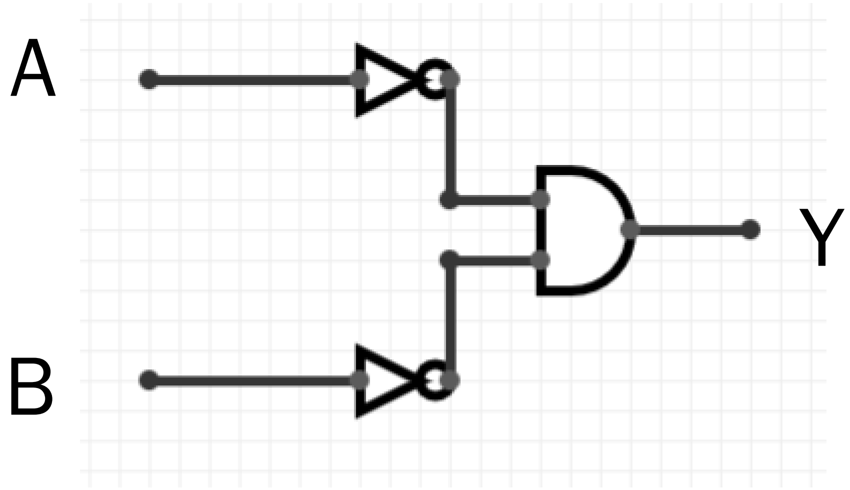
7.2 Implementation Procedures

Consider it as SOP form, then consider the '1' (if you choose POS form, consider '0')



7.2 Implementation Procedures

Draw the logic diagram



7.3 Adder

7.3 Adder

Half Adder

- Half adder is a combinational logic circuit designed to add two single bit numbers
- It contains two inputs and two outputs

Inputs		Outputs	
A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

7.3 Adder

K-MAP for Sum

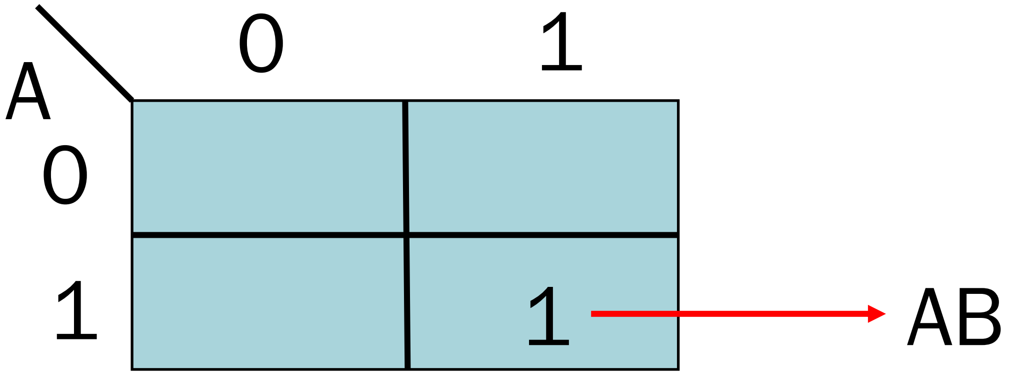
A	0	1
0		1
1	1	

A’B + AB’

A XOR B

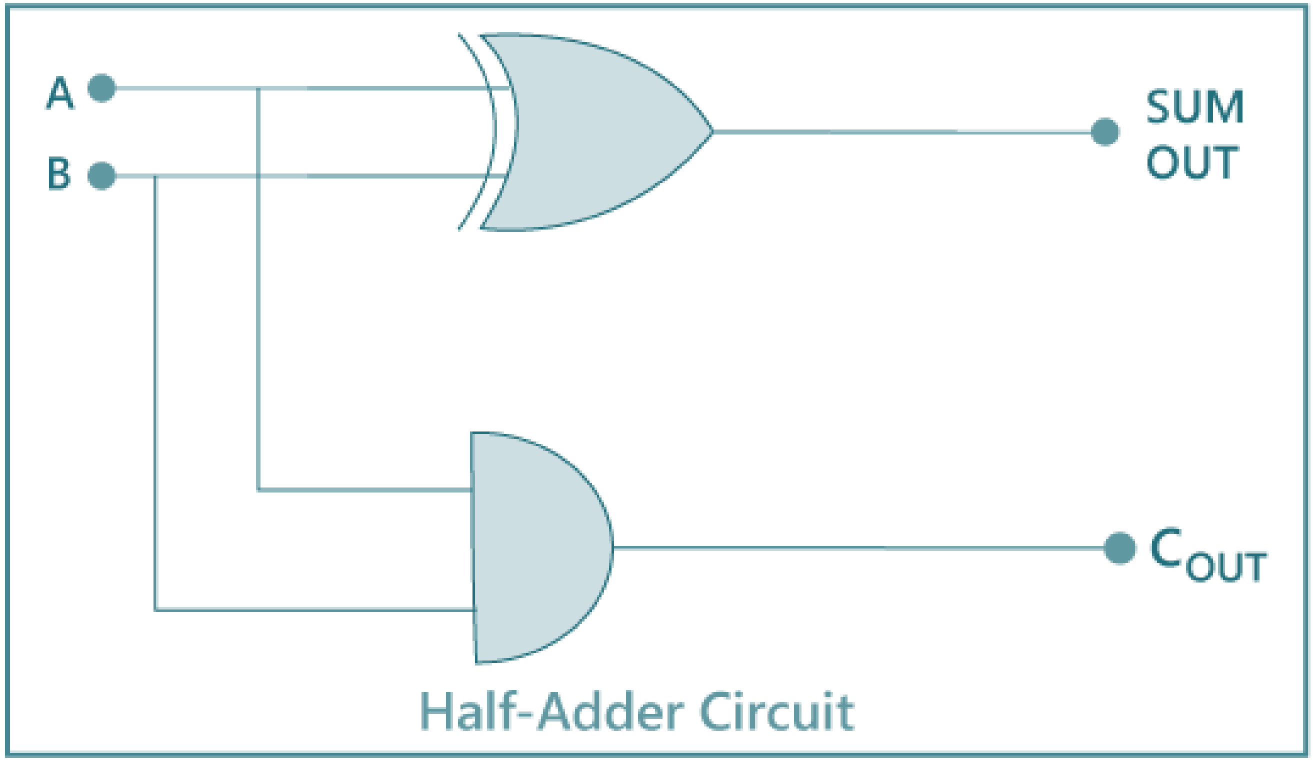
7.3 Adder

K-MAP for Carry



7.3 Adder

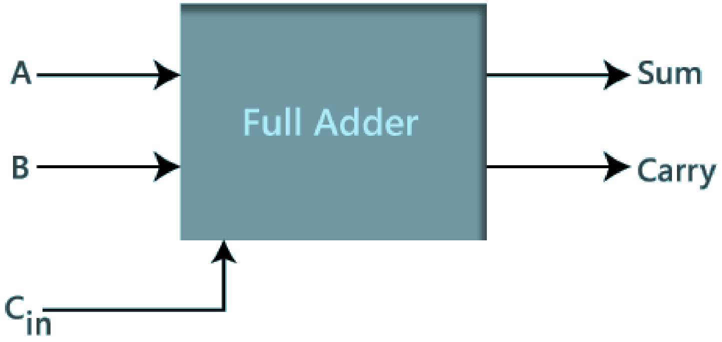
Half adder circuit



7.3 Adder

Full Adder

- Full adder is arithmetic logic circuit designed to add single bit numbers with a carry



Inputs			Outputs	
A	B	C_{in}	Sum	Carry
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

7.3 Adder

K-MAP for Sum

A \ BC	00	01	11	10
0		1		1
1	1		1	

A XOR B XOR C

7.3 Adder

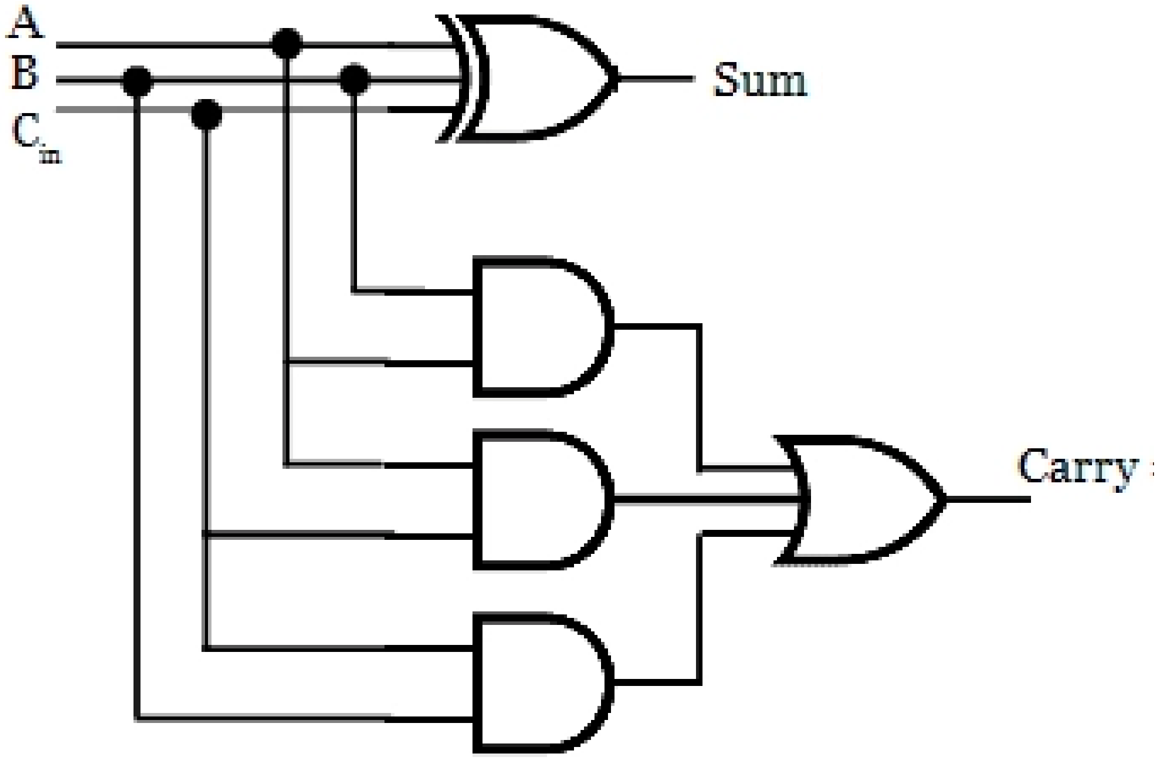
K-MAP for Carry

A \ BC	00	01	11	10
0			1	
1		1	1	1

AC + BC +AB

7.3 Adder

Full adder circuit



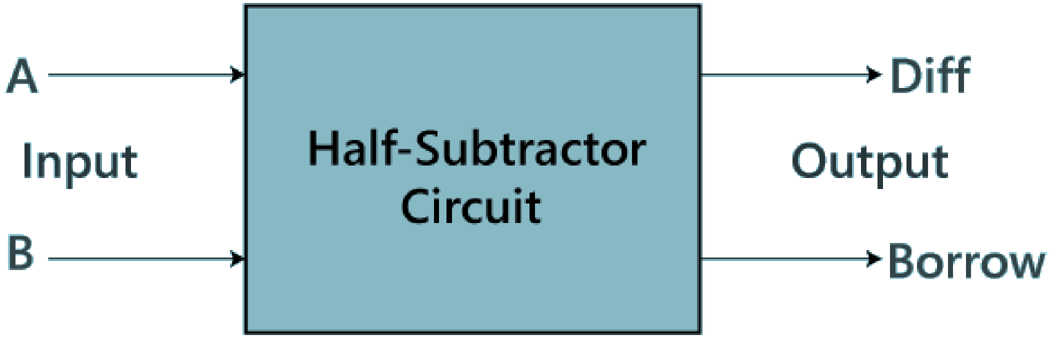
7.4 Subtractor

7.4 Subtractor

Half Subtractor

- Half subtractor is a combinational circuit used to get the difference between two single bit

Inputs		Outputs	
A	B	Diff	Borrow
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0



7.4 Subtractor

K-MAP for Difference

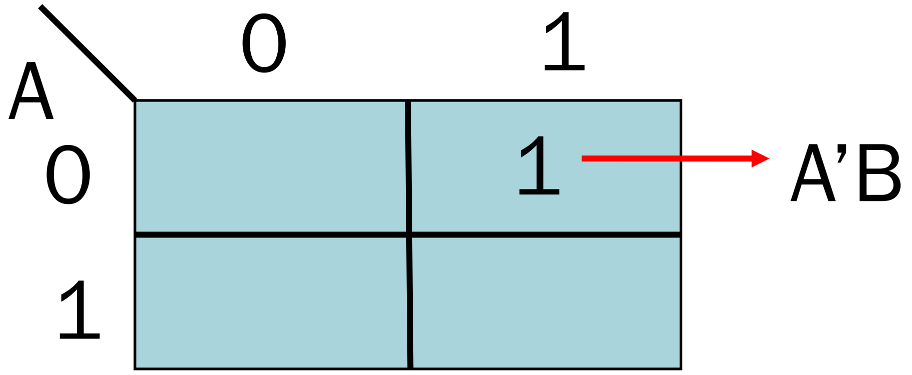
A	0	1
0		1
1	1	

A'B + AB'

A XOR B

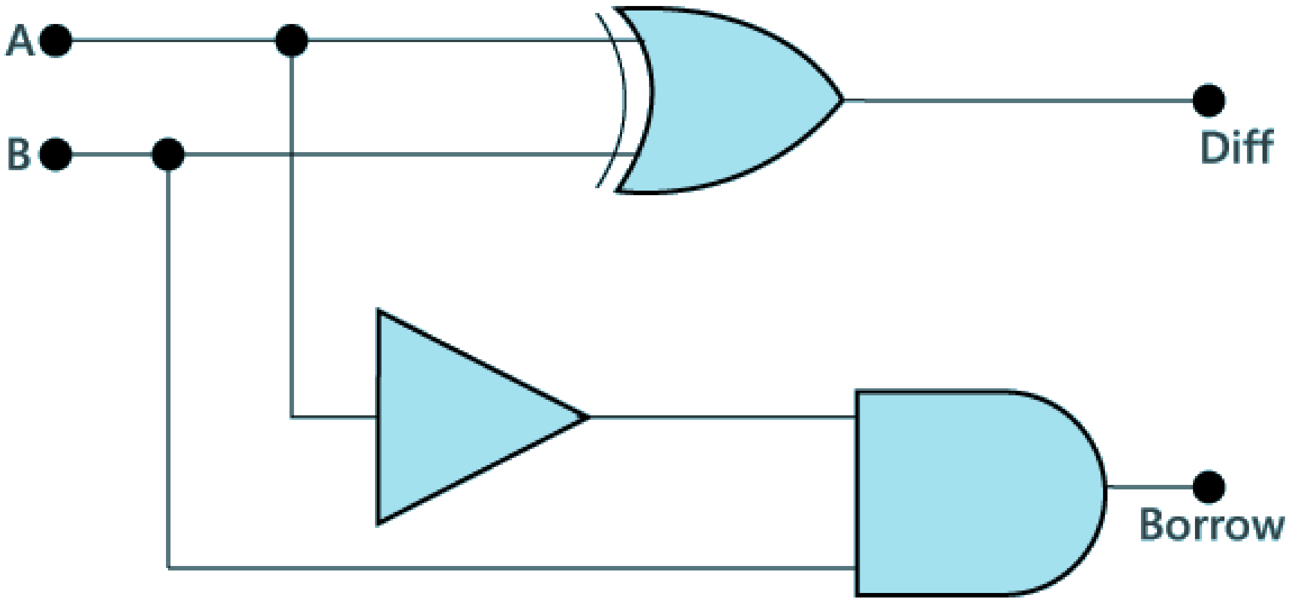
7.4 Subtractor

K-MAP for Borrow



7.4 Subtractor

Half Subtractor circuit

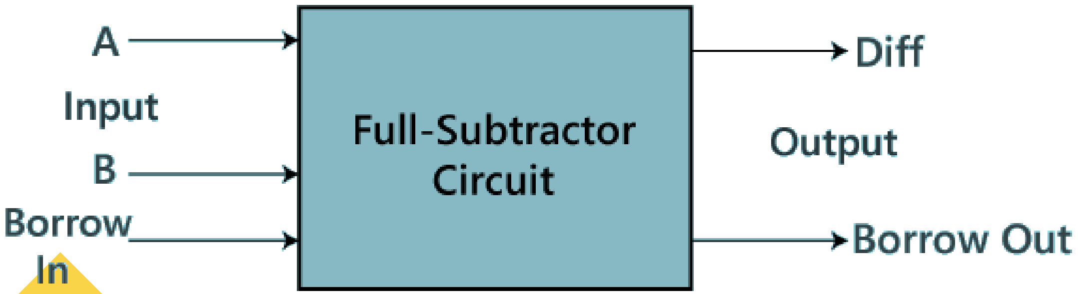


Half-Subtractor Circuit

7.4 Subtractor

Full Subtractor

- Full subtractor is a combinational circuit used to perform subtraction among 3 bit



Inputs			Outputs	
A	B	$Borrow_{in}$	Diff	Borrow
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

7.4 Subtractor

K-MAP for Difference

A \ B Bin	00	01	11	10
0		1		1
1	1		1	

A XOR B XOR Bin

7.4 Subtractor

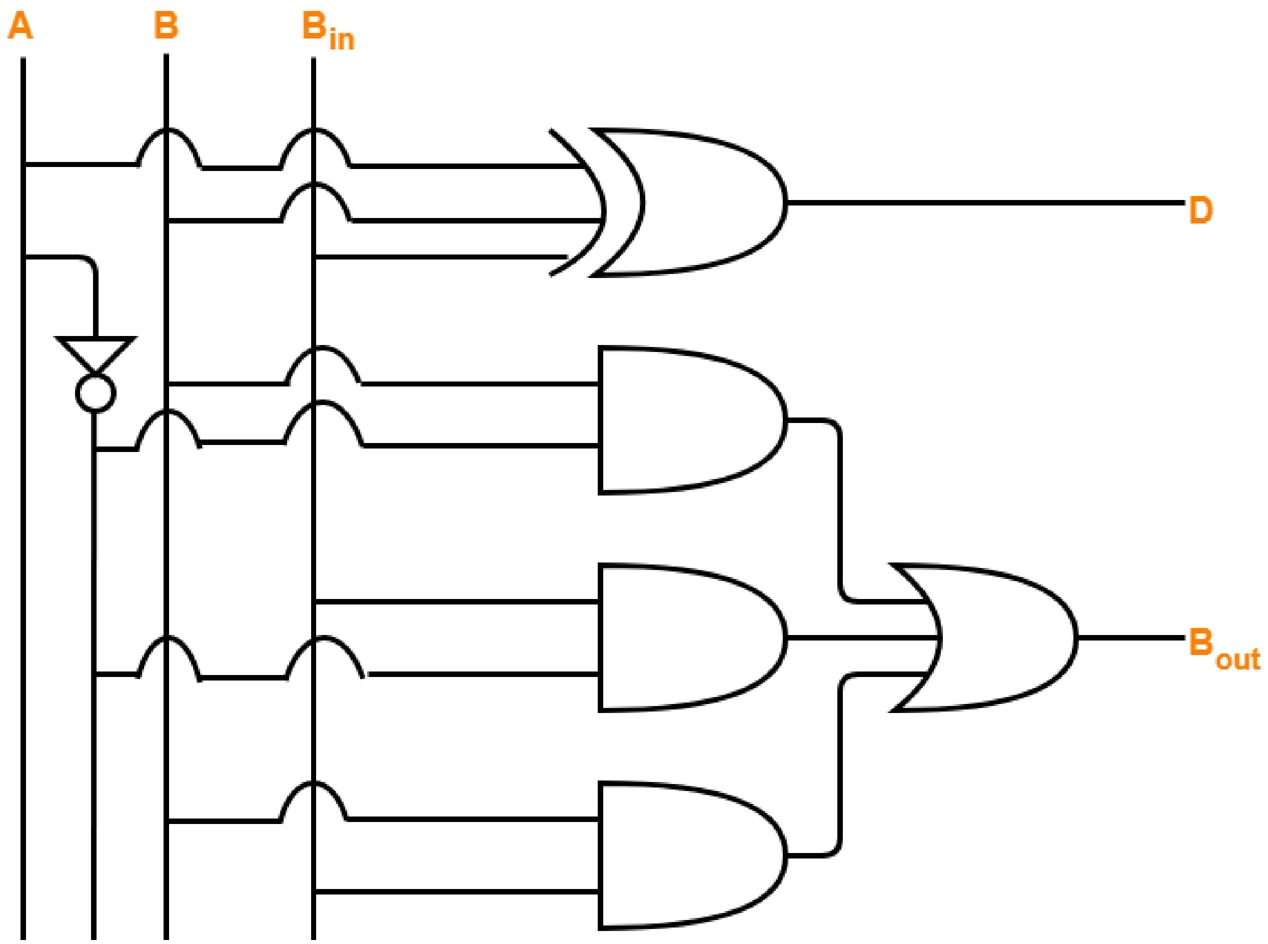
K-MAP for Borrow out

A \ B Bin	00	01	11	10
0		1	1	1
1			1	

B Bin + A’B + A’Bin

7.4 Subtractor

Full Subtractor circuit



7.5 Code Conversion

7.5 Code Conversion

- Code converter is used to convert one type of binary code to another
- There are 3 different types of binary codes, like BCD code, gray code, and excess-3 code
- In this topic, we will learn 2 different converter
  - Binary to Gray Code Converter
  - Binary to BCD Code Converter

7.5 Code Conversion

Binary to Gray Code Converter

Decimal	Binary	Gray Code
0	000	000
1	001	001
2	010	011
3	011	010
4	100	110
5	101	111
6	110	101
7	111	100

7.5 Code Conversion

K-MAP for D

A \ BC	00	01	11	10
0				
1	1	1	1	1

$$D = A$$

K-MAP for E

A \ BC	00	01	11	10
0			1	1
1	1	1		

$$E = A'B + AB' = A \text{ XOR } B$$

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7.5 Code Conversion

K-MAP for F

A \ B C	00	01	11	10
0		1		1
1		1		1

F= B'C + BC' = B XOR C

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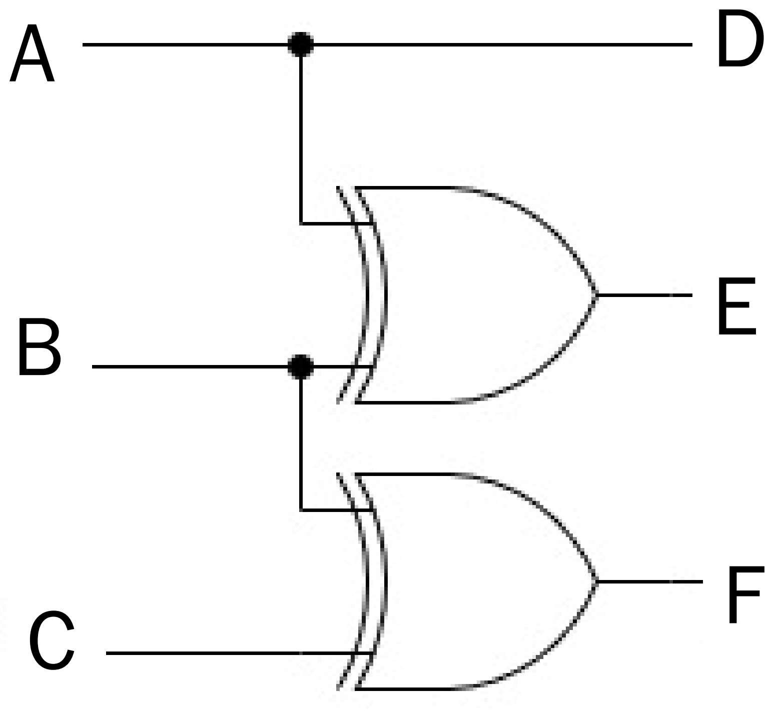
7.5 Code Conversion

Binary to Gray Code Converter Circuit



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7.5 Code Conversion

Binary to BCD Converter

	Binary Code (Input)				BCD Code (Output)				
0	*A*	*B*	*C*	*D*	*W*	*X*	*Y*	*Z*	*E*
1	0	0	0	0	0	0	0	0	0
2	0	0	0	1	0	0	0	0	1
3	0	0	1	0	0	0	0	1	0
4	0	0	1	1	0	0	0	1	1
5	0	1	0	0	0	0	1	0	0
6	0	1	0	1	0	0	1	0	1
7	0	1	1	0	0	0	1	1	0

7.5 Code Conversion

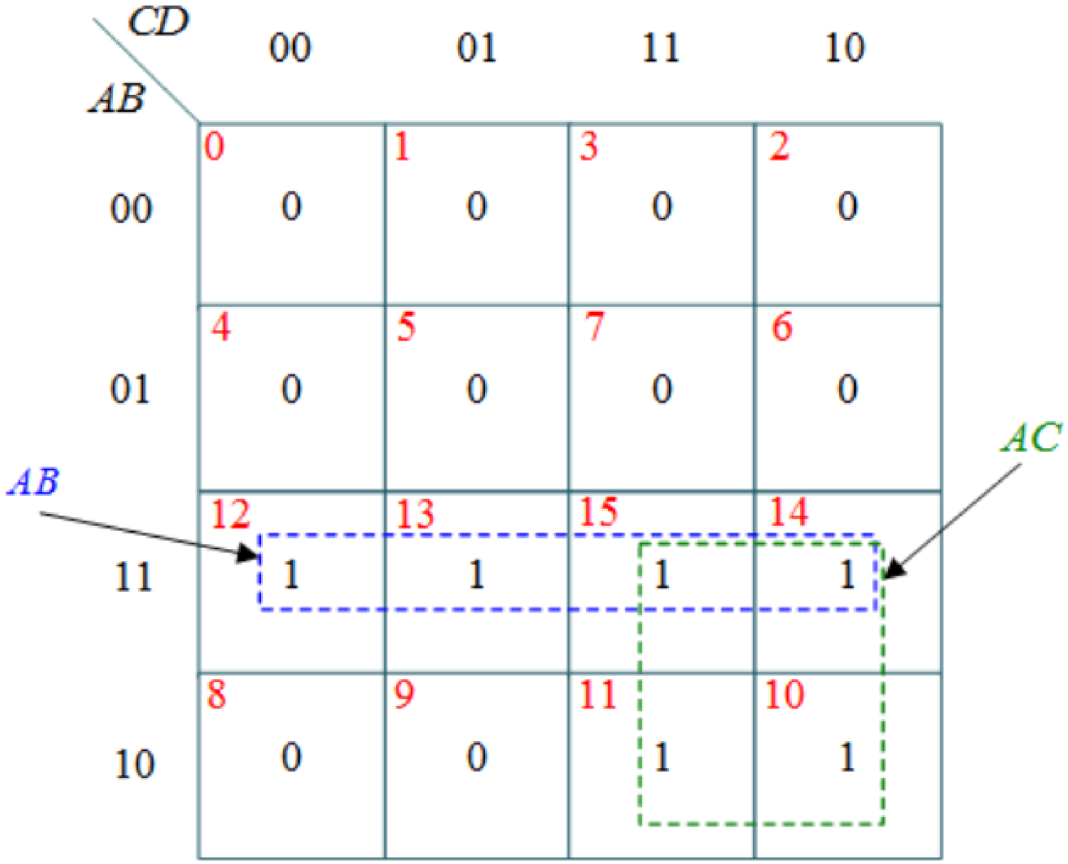
Cont..

	Binary Code (Input)				BCD Code (Output)				
	A	*B*	*C*	*D*	*W*	*X*	*Y*	*Z*	*E*
8	1	0	0	0	0	1	0	0	0
9	1	0	0	1	0	1	0	0	1
10	1	0	1	0	1	0	0	0	0
11	1	0	1	1	1	0	0	0	1
12	1	1	0	0	1	0	0	1	0
13	1	1	0	1	1	0	0	1	1
14	1	1	1	0	1	0	1	0	0
15	1	1	1	1	1	0	1	0	1

7.5 Code Conversion

K-MAP for W

W = AB + AC



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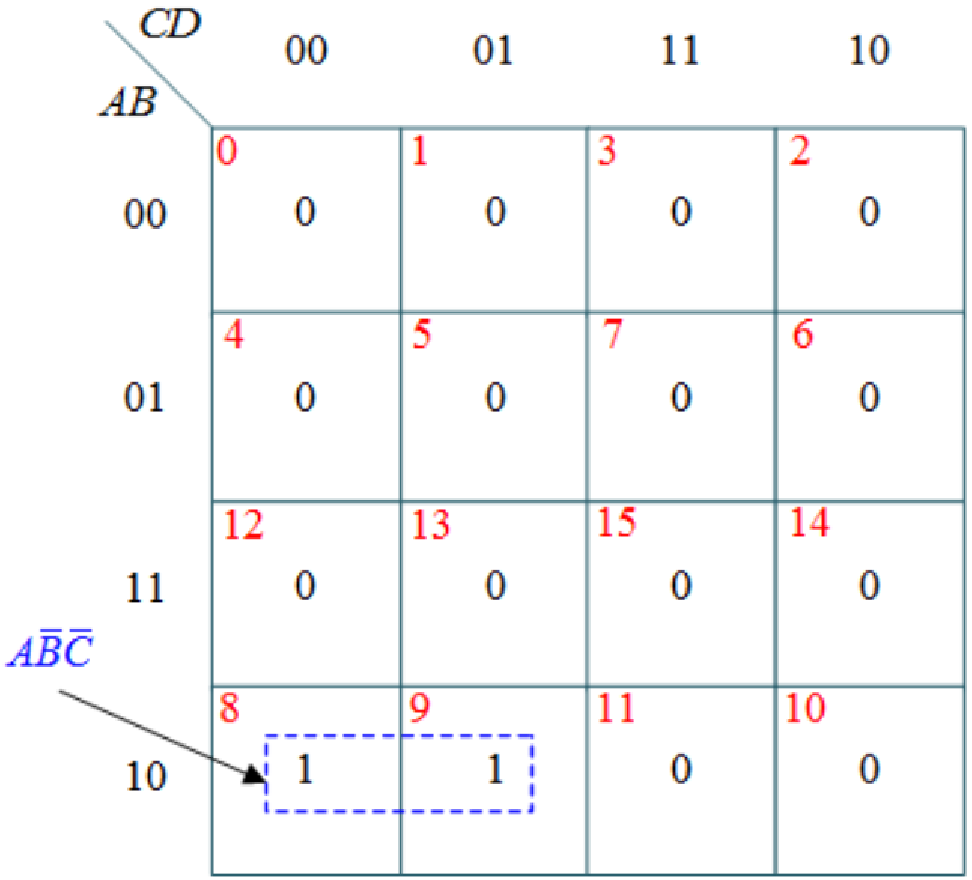
7.5 Code Conversion

K-MAP for X

X = AB’C’



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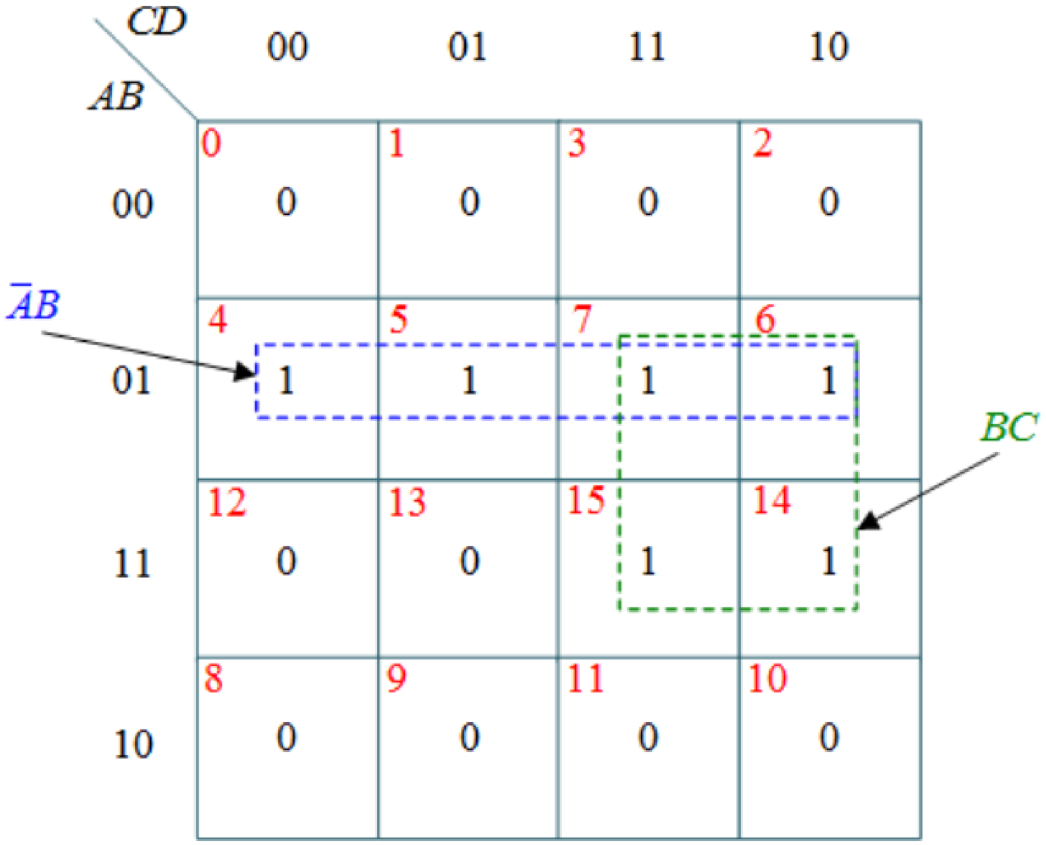
7.5 Code Conversion

K-MAP for Y

Y = A'B + BC



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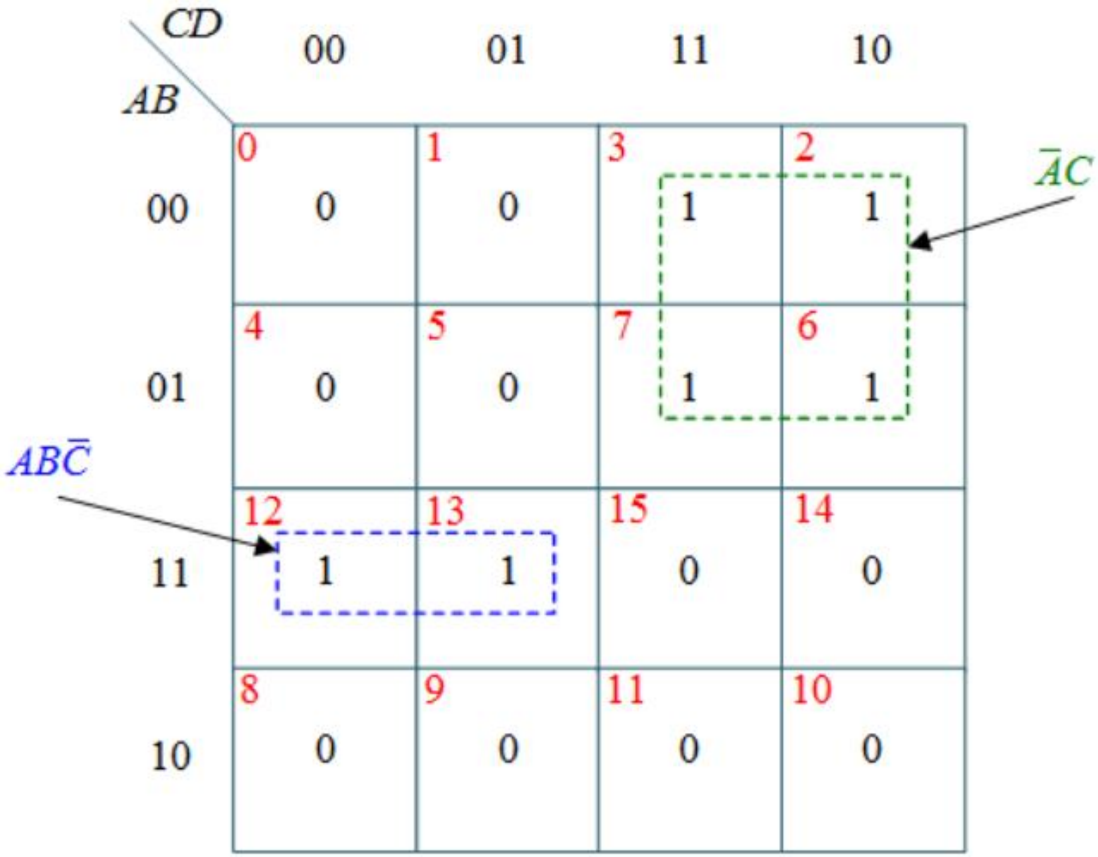
7.5 Code Conversion

K-MAP for Z

Z = ABC’ + A’C



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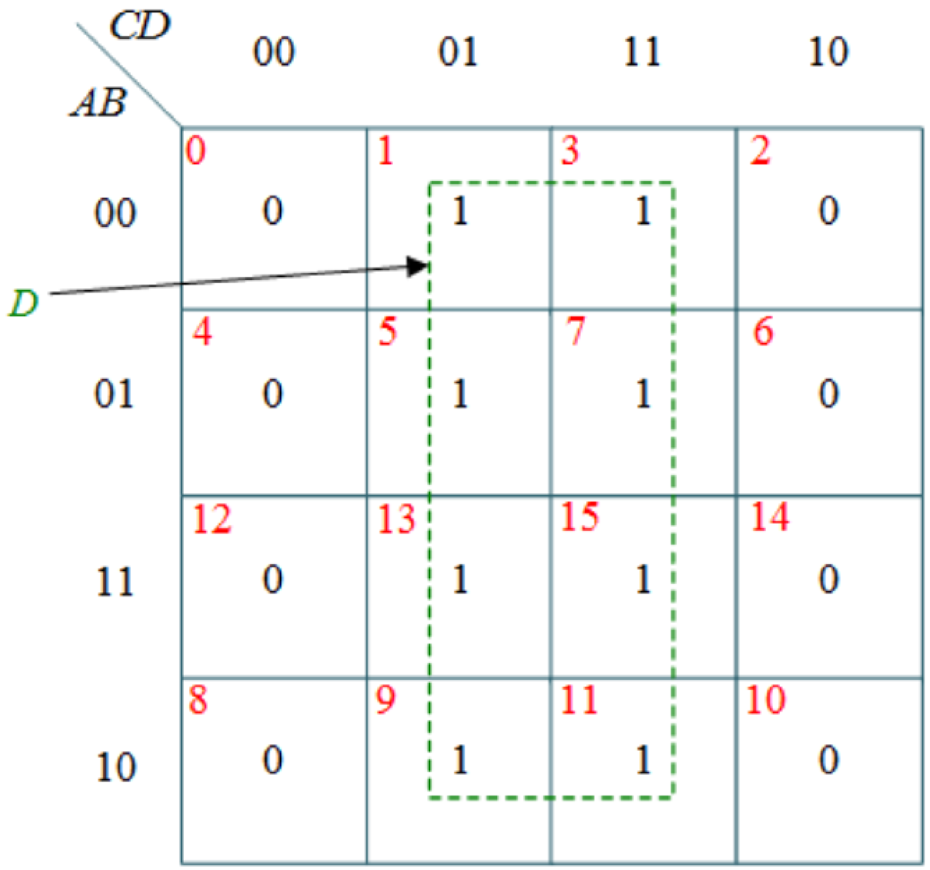
7.5 Code Conversion

K-MAP for E

E=D



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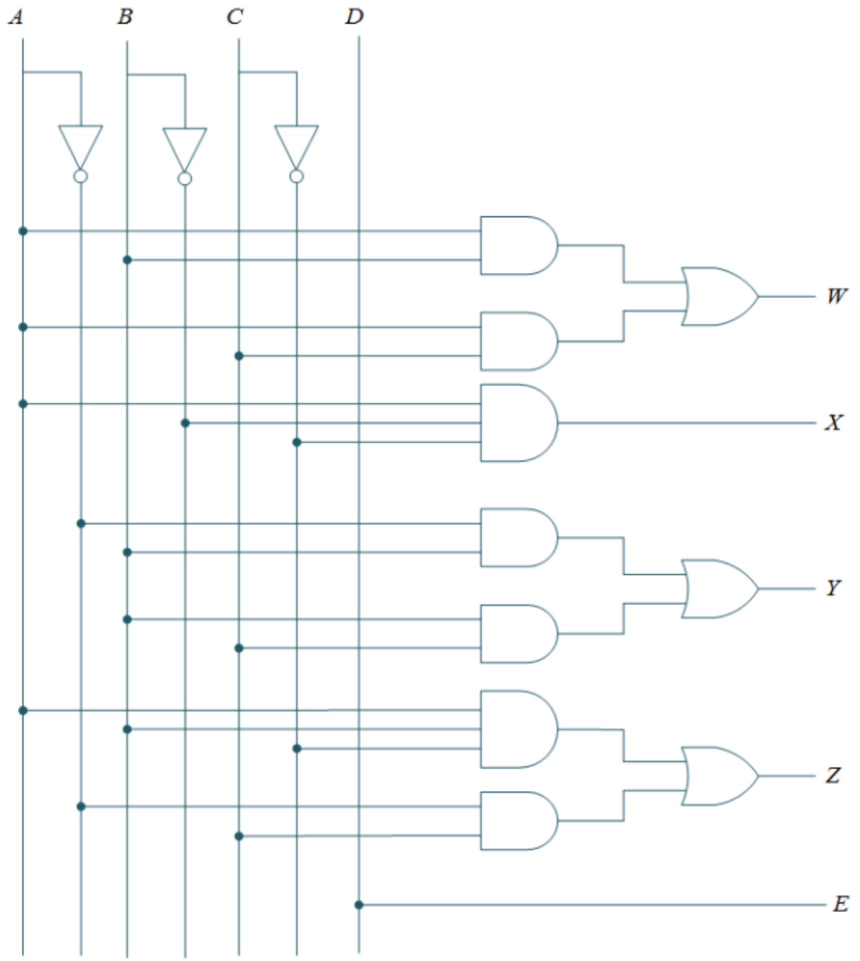
7.5 Code Conversion

Binary to BCD Converter



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References

M. Morris Mano, Digital Design, 5th ed, Prentice Hall, 2012, **Chapter 4**

Next Topic : Combinational Logic Circuit (2)