



# SNS COLLEGE OF ENGINEERING

(Autonomous)

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING



## 1EC306 Digital Electronics

AB	CD			
	00	01	11	10
00				
01			0	0
11	X	X	X	X
10	0	0	X	X

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



Guess today's topic???





# Karnaugh Map



- A visual way to simplify logic expressions
- It gives the most simplified form of the expression
- A Karnaugh map is a graphical method used to obtain the most simplified form of an expression in a standard form (Sum-of-Products or Product-of-Sums).
- The simplest form of an expression is the one that has the minimum number of terms with the least number of literals (variables) in each term.
- By simplifying an expression to the one that uses the minimum number of terms, we ensure that the function will be implemented with the minimum number of gates.



# 3 variable k-map

$$f = \sum(0,4) = \bar{B}\bar{C}$$

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

$$f = \sum(4,5) = A\bar{B}$$

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

$$f = \sum(0,1,4,5) = \bar{B}$$

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

$$f = \sum(0,1,2,3) = \bar{A}$$

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

$$f = \sum(0,4) = \bar{A}C$$

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

$$f = \sum(4,6) = A\bar{C}$$

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

$$f = \sum(0,2) = \bar{A}\bar{C}$$

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

$$f = \sum(0,2,4,6) = \bar{C}$$

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



# 3 variable K-Map-Assessment

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

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

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

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

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

	BC			
A	00	01	11	10
0				
1				



# 4 variable K-Map

- Click to add text

	CD			
AB	00	01	11	10
00	1	0	0	0
01	0	0	0	0
11	0	0	0	0
10	1	0	0	0

$$f = \sum(0,8) = \bar{B} \cdot \bar{C} \cdot \bar{D}$$

	CD			
AB	00	01	11	10
00	0	0	0	0
01	0	1	0	0
11	0	1	0	0
10	0	0	0	0

$$f = \sum(5,13) = B \cdot \bar{C} \cdot D$$

	CD			
AB	00	01	11	10
00	0	0	0	0
01	0	0	0	0
11	0	1	1	0
10	0	0	0	0

$$f = \sum(13,15) = A \cdot B \cdot D$$

	CD			
AB	00	01	11	10
00	0	0	0	0
01	1	0	0	1
11	0	0	0	0
10	0	0	0	0

$$f = \sum(4,6) = \bar{A} \cdot B \cdot \bar{D}$$

	CD			
AB	00	01	11	10
00	0	0	1	1
01	0	0	1	1
11	0	0	0	0
10	0	0	0	0

$$f = \sum(2,3,6,7) = \bar{A} \cdot C$$

	CD			
AB	00	01	11	10
00	0	0	0	0
01	1	0	0	1
11	1	0	0	1
10	0	0	0	0

$$f = \sum(4,6,12,14) = B \cdot \bar{D}$$

	CD			
AB	00	01	11	10
00	0	0	1	1
01	0	0	0	0
11	0	0	0	0
10	0	0	1	1

$$f = \sum(2,3,10,11) = \bar{B} \cdot C$$

	CD			
AB	00	01	11	10
00	1	0	0	1
01	0	0	0	0
11	0	0	0	0
10	1	0	0	1

$$f = \sum(0,2,8,10) = \bar{B} \cdot \bar{D}$$



# Cell adjacency

<p>Click to add text</p> <table border="1"> <tr><td>CD</td><td>00</td><td>01</td><td>11</td><td>10</td></tr> <tr><td>AB</td><td>00</td><td>0</td><td>0</td><td>0</td><td>0</td></tr> <tr><td></td><td>01</td><td>1</td><td>1</td><td>1</td><td>1</td></tr> <tr><td></td><td>11</td><td>0</td><td>0</td><td>0</td><td>0</td></tr> <tr><td></td><td>10</td><td>0</td><td>0</td><td>0</td><td>0</td></tr> </table> <p><math>f = \sum(4,5,6,7) = \bar{A} \cdot B</math></p>	CD	00	01	11	10	AB	00	0	0	0	0		01	1	1	1	1		11	0	0	0	0		10	0	0	0	0	<table border="1"> <tr><td>CD</td><td>00</td><td>01</td><td>11</td><td>10</td></tr> <tr><td>AB</td><td>00</td><td>0</td><td>0</td><td>1</td><td>0</td></tr> <tr><td></td><td>01</td><td>0</td><td>0</td><td>1</td><td>0</td></tr> <tr><td></td><td>11</td><td>0</td><td>0</td><td>1</td><td>0</td></tr> <tr><td></td><td>10</td><td>0</td><td>0</td><td>1</td><td>0</td></tr> </table> <p><math>f = \sum(3,7,11,15) = C \cdot D</math></p>	CD	00	01	11	10	AB	00	0	0	1	0		01	0	0	1	0		11	0	0	1	0		10	0	0	1	0	<table border="1"> <tr><td>CD</td><td>00</td><td>01</td><td>11</td><td>10</td></tr> <tr><td>AB</td><td>00</td><td>1</td><td>0</td><td>1</td><td>0</td></tr> <tr><td></td><td>01</td><td>0</td><td>1</td><td>0</td><td>1</td></tr> <tr><td></td><td>11</td><td>1</td><td>0</td><td>1</td><td>0</td></tr> <tr><td></td><td>10</td><td>0</td><td>1</td><td>0</td><td>1</td></tr> </table> <p><math>f = \sum(0,3,5,6,9,10,12,15)</math> <math>f = A \otimes B \otimes C \otimes D</math></p>	CD	00	01	11	10	AB	00	1	0	1	0		01	0	1	0	1		11	1	0	1	0		10	0	1	0	1	<table border="1"> <tr><td>CD</td><td>00</td><td>01</td><td>11</td><td>10</td></tr> <tr><td>AB</td><td>00</td><td>0</td><td>1</td><td>0</td><td>1</td></tr> <tr><td></td><td>01</td><td>1</td><td>0</td><td>1</td><td>0</td></tr> <tr><td></td><td>11</td><td>0</td><td>1</td><td>0</td><td>1</td></tr> <tr><td></td><td>10</td><td>1</td><td>0</td><td>1</td><td>0</td></tr> </table> <p><math>f = \sum(1,2,4,7,8,11,13,14)</math> <math>f = A \oplus B \oplus C \oplus D</math></p>	CD	00	01	11	10	AB	00	0	1	0	1		01	1	0	1	0		11	0	1	0	1		10	1	0	1	0
CD	00	01	11	10																																																																																																																			
AB	00	0	0	0	0																																																																																																																		
	01	1	1	1	1																																																																																																																		
	11	0	0	0	0																																																																																																																		
	10	0	0	0	0																																																																																																																		
CD	00	01	11	10																																																																																																																			
AB	00	0	0	1	0																																																																																																																		
	01	0	0	1	0																																																																																																																		
	11	0	0	1	0																																																																																																																		
	10	0	0	1	0																																																																																																																		
CD	00	01	11	10																																																																																																																			
AB	00	1	0	1	0																																																																																																																		
	01	0	1	0	1																																																																																																																		
	11	1	0	1	0																																																																																																																		
	10	0	1	0	1																																																																																																																		
CD	00	01	11	10																																																																																																																			
AB	00	0	1	0	1																																																																																																																		
	01	1	0	1	0																																																																																																																		
	11	0	1	0	1																																																																																																																		
	10	1	0	1	0																																																																																																																		
<table border="1"> <tr><td>CD</td><td>00</td><td>01</td><td>11</td><td>10</td></tr> <tr><td>AB</td><td>00</td><td>0</td><td>1</td><td>1</td><td>0</td></tr> <tr><td></td><td>01</td><td>0</td><td>1</td><td>1</td><td>0</td></tr> <tr><td></td><td>11</td><td>0</td><td>1</td><td>1</td><td>0</td></tr> <tr><td></td><td>10</td><td>0</td><td>1</td><td>1</td><td>0</td></tr> </table> <p><math>f = \sum(1,3,5,7,9,11,13,15)</math> <math>f = D</math></p>	CD	00	01	11	10	AB	00	0	1	1	0		01	0	1	1	0		11	0	1	1	0		10	0	1	1	0	<table border="1"> <tr><td>CD</td><td>00</td><td>01</td><td>11</td><td>10</td></tr> <tr><td>AB</td><td>00</td><td>1</td><td>0</td><td>0</td><td>1</td></tr> <tr><td></td><td>01</td><td>1</td><td>0</td><td>0</td><td>1</td></tr> <tr><td></td><td>11</td><td>1</td><td>0</td><td>0</td><td>1</td></tr> <tr><td></td><td>10</td><td>1</td><td>0</td><td>0</td><td>1</td></tr> </table> <p><math>f = \sum(0,2,4,6,8,10,12,14)</math> <math>f = \bar{D}</math></p>	CD	00	01	11	10	AB	00	1	0	0	1		01	1	0	0	1		11	1	0	0	1		10	1	0	0	1	<table border="1"> <tr><td>CD</td><td>00</td><td>01</td><td>11</td><td>10</td></tr> <tr><td>AB</td><td>00</td><td>0</td><td>0</td><td>0</td><td>0</td></tr> <tr><td></td><td>01</td><td>1</td><td>1</td><td>1</td><td>1</td></tr> <tr><td></td><td>11</td><td>1</td><td>1</td><td>1</td><td>1</td></tr> <tr><td></td><td>10</td><td>0</td><td>0</td><td>0</td><td>0</td></tr> </table> <p><math>f = \sum(4,5,6,7,12,13,14,15)</math> <math>f = B</math></p>	CD	00	01	11	10	AB	00	0	0	0	0		01	1	1	1	1		11	1	1	1	1		10	0	0	0	0	<table border="1"> <tr><td>CD</td><td>00</td><td>01</td><td>11</td><td>10</td></tr> <tr><td>AB</td><td>00</td><td>1</td><td>1</td><td>1</td><td>1</td></tr> <tr><td></td><td>01</td><td>0</td><td>0</td><td>0</td><td>0</td></tr> <tr><td></td><td>11</td><td>0</td><td>0</td><td>0</td><td>0</td></tr> <tr><td></td><td>10</td><td>1</td><td>1</td><td>1</td><td>1</td></tr> </table> <p><math>f = \sum(0,1,2,3,8,9,10,11)</math> <math>f = \bar{B}</math></p>	CD	00	01	11	10	AB	00	1	1	1	1		01	0	0	0	0		11	0	0	0	0		10	1	1	1	1
CD	00	01	11	10																																																																																																																			
AB	00	0	1	1	0																																																																																																																		
	01	0	1	1	0																																																																																																																		
	11	0	1	1	0																																																																																																																		
	10	0	1	1	0																																																																																																																		
CD	00	01	11	10																																																																																																																			
AB	00	1	0	0	1																																																																																																																		
	01	1	0	0	1																																																																																																																		
	11	1	0	0	1																																																																																																																		
	10	1	0	0	1																																																																																																																		
CD	00	01	11	10																																																																																																																			
AB	00	0	0	0	0																																																																																																																		
	01	1	1	1	1																																																																																																																		
	11	1	1	1	1																																																																																																																		
	10	0	0	0	0																																																																																																																		
CD	00	01	11	10																																																																																																																			
AB	00	1	1	1	1																																																																																																																		
	01	0	0	0	0																																																																																																																		
	11	0	0	0	0																																																																																																																		
	10	1	1	1	1																																																																																																																		



# Design of combinational Digital Circuits

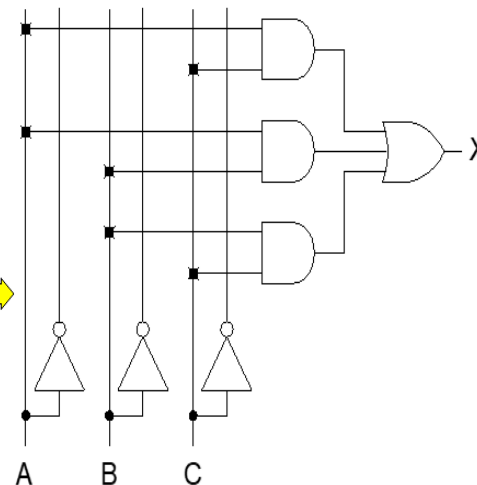
- Steps to design a combinational digital circuit:
  - From the problem statement derive the truth table
  - From the truth table derive the unsimplified logic expression
  - Simplify the logic expression
  - From the simplified expression draw the logic circuit
- Example: Design a 3-input (A,B,C) digital circuit that will give at its output (X) a logic 1 only if the binary number formed at the input has more ones than zeros.

	Inputs			Output
	A	B	C	
0	0	0	0	0
1	0	0	1	0
2	0	1	0	0
3	0	1	1	1
4	1	0	0	0
5	1	0	1	1
6	1	1	0	1
7	1	1	1	1

$$X = \sum(3, 5, 6, 7)$$

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

$$X = AC + AB + BC$$



# Design of combinational Digital Circuits

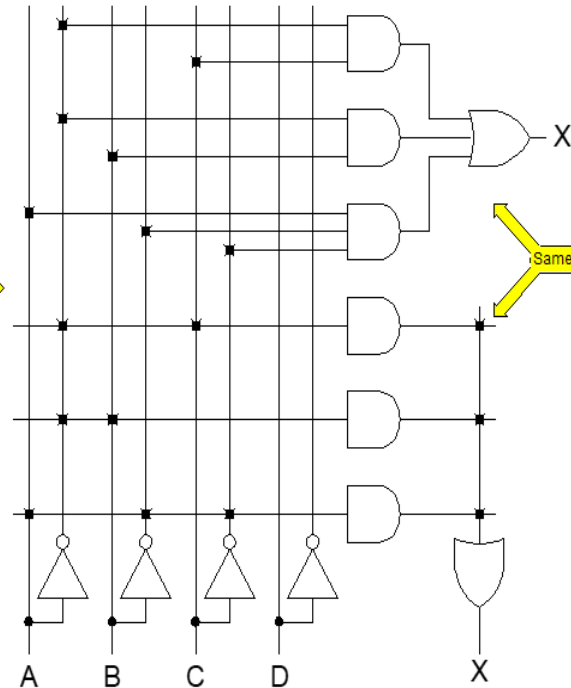
- Example: Design a 4-input (A,B,C,D) digital circuit that will give at its output (X) a logic 1 only if the binary number formed at the input is between 2 and 9 (including).

	Inputs				Output
	A	B	C	D	
0	0	0	0	0	0
1	0	0	0	1	0
2	0	0	1	0	1
3	0	0	1	1	1
4	0	1	0	0	1
5	0	1	0	1	1
6	0	1	1	0	1
7	0	1	1	1	1
8	1	0	0	0	1
9	1	0	0	1	1
10	1	0	1	0	0
11	1	0	1	1	0
12	1	1	0	0	0
13	1	1	0	1	0
14	1	1	1	0	0
15	1	1	1	1	0

$X = \sum(2,3,4,5,6,7,8,9)$

AB \ CD	CD			
	00	01	11	10
00	0	0	1	1
01	1	1	1	1
11	0	0	0	0
10	1	1	0	0

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





- Example: Design a 4-input (A,B,C,D) digital circuit that will give at its output (X) a logic 1 only if there more ones than zeros in the binary number formed at the input.

	Inputs				Output	
	A	B	C	D		
0	0	0	0	0		
1	0	0	0	1		
2	0	0	1	0		
3	0	0	1	1		
4	0	1	0	0		
5	0	1	0	1		
6	0	1	1	0		
7	0	1	1	1		
8	1	0	0	0		
9	1	0	0	1		
10	1	0	1	0		
11	1	0	1	1		
12	1	1	0	0		
13	1	1	0	1		
14	1	1	1	0		
15	1	1	1	1		

X =

		CD		
	AB		00	01
		00		
		01		
		11		
		10		

X =

