

Digital Logic Design (ESC-151)

Abdul Rehman

email id:- abdul@northern.edu.pk

Whatsapp#03087792217

Note:

It is intimated that following Lectures will not be repeated and would be part of mid-term & final exam as well.

Objectives:

The objective for this week will be to understand 4 and 5 variable SOP K maps, 2,3,4,5 variable POS Kmaps and combinational circuit designing

- K maps
- Circuit Designing

LECTURE-11

In this lecture we will continue from previous lecture where we stopped. Last time we were discussing Kmaps for SOP equations and we will complete our discussion on SOP K maps along with K maps for POS equations.

4 variable Kmaps:

EXAMPLE-1:

Handwritten notes on lined paper for a 4-variable K-map (SOP) example.

Header: Name of Aun _____ BS-CS/MCS Digital Logic Design

4 variable K-maps (SOP)

① $\bar{A}\bar{B}\bar{C}\bar{D} + \bar{A}\bar{B}\bar{C}D + \bar{A}\bar{B}C\bar{D} + \bar{A}\bar{B}CD + \bar{A}B\bar{C}\bar{D} + \bar{A}B\bar{C}D + \bar{A}BC\bar{D} + \bar{A}BCD$
0000 0001 0100 1001 0110 1011 1010

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

Groupings (circles):

- ① $\bar{A}\bar{B}\bar{C}\bar{D}$ (0000)
- ② $\bar{A}\bar{B}\bar{C}D$ (0001)
- ③ $\bar{A}\bar{B}C\bar{D}$ (0100)
- ④ $\bar{A}\bar{B}CD$ (0101)
- ⑤ $\bar{A}B\bar{C}\bar{D}$ (1000)
- ⑥ $\bar{A}B\bar{C}D$ (1001)
- ⑦ $\bar{A}BC\bar{D}$ (1010)
- ⑧ $\bar{A}BCD$ (1011)

Final Expression: $= \bar{A}\bar{C}\bar{D} + \bar{A}\bar{B}\bar{C} + \bar{B}\bar{C}\bar{D} + \bar{A}B\bar{D}$

EXAMPLE-2:

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Abdul Rehman

email id:- abdul@northern.edu.pk

Whatsapp#03087792217

② $\bar{A}\bar{B}\bar{C}\bar{D} + \bar{A}\bar{B}\bar{C}D + \bar{A}\bar{B}C\bar{D} + \bar{A}\bar{B}CD + A\bar{B}\bar{C}\bar{D} + A\bar{B}\bar{C}D + A\bar{B}C\bar{D} + A\bar{B}CD$
 0000 0010 0100 1001 1100 1110 1000 1010

	CD							
	00	01	11	10				
AB	00	01	11	10	①	②	③	④
00	1			1	$\bar{A}\bar{B}\bar{C}\bar{D}$	$\bar{A}\bar{B}\bar{C}D$	$\bar{A}\bar{B}C\bar{D}$	$\bar{A}\bar{B}CD$
01	1				0000	0001	0000	0000
11	1			1	0100	0100	1001	0010
10	1	1		1	1100	1110	$\bar{A}BC$	1000
					1000	1010		1010

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

EXAMPLE-3:

③

	CD				
	00	01	11	10	
AB	00	01	11	10	$\bar{A}\bar{B}\bar{C}\bar{D}$
00	1			1	0000
01	1			1	0010
11	1			1	0100
10	1			1	1100

$= \bar{D}$

EXAMPLE-4:

④

	CD				
	00	01	11	10	
AB	00	01	11	10	$\bar{A}\bar{B}\bar{C}\bar{D}$
00	1			1	0000
01					0010
11					1000
10	1			1	1010

$= \bar{B}\bar{D}$

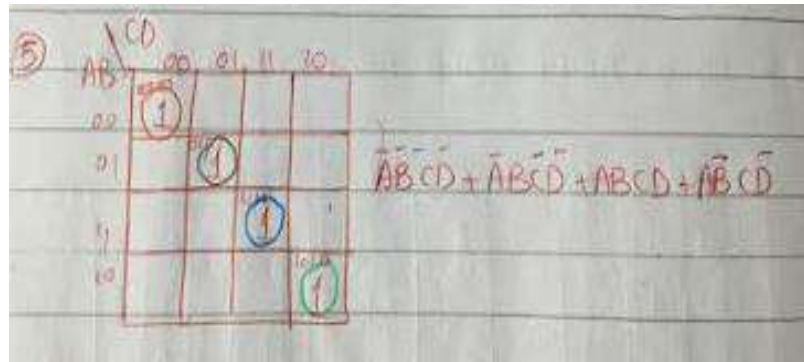
EXAMPLE-5:

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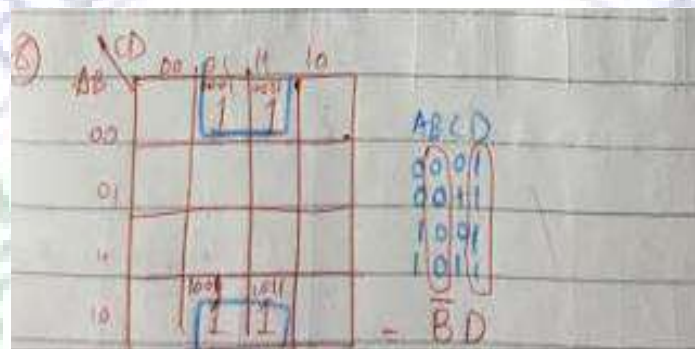
Abdul Rehman

email id:- abdul@northern.edu.pk

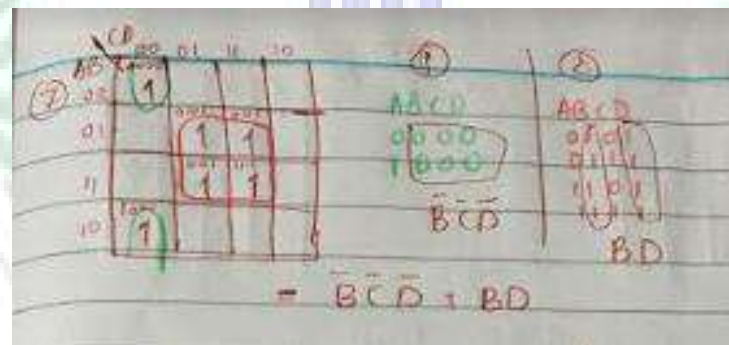
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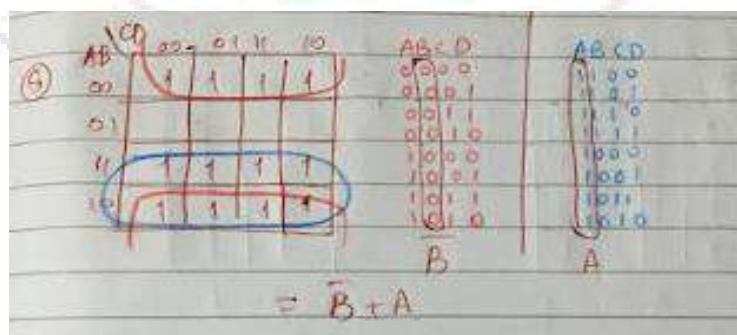
EXAMPLE-6:



EXAMPLE-7:



EXAMPLE-8:



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email id:- abdul@northern.edu.pk

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5 variable SOP K maps

A	B	C	D	E
0	0	0	0	0
0	0	0	0	1
0	0	0	1	0
0	0	0	1	1
0	0	1	0	0
0	0	1	0	1
0	0	1	1	0
0	0	1	1	1
0	1	0	0	0
0	1	0	0	1
0	1	0	1	0
0	1	0	1	1
0	1	1	0	0
0	1	1	0	1
0	1	1	1	0
0	1	1	1	1

1	0	0	0	0
1	0	0	0	1
1	0	0	1	0
1	0	0	1	1
1	0	1	0	0
1	0	1	0	1
1	0	1	1	0
1	0	1	1	1
1	1	0	0	0
1	1	0	0	1
1	1	0	1	0
1	1	0	1	1
1	1	1	0	0
1	1	1	0	1
1	1	1	1	0
1	1	1	1	1

A=0

A=1

BC \ DE	DE			
	00	01	11	10
00	$B'C'D'E'$ ⁰	$B'C'D'E$ ¹	$B'C'DE$ ³	$B'C'DE'$ ²
01	$B'CD'E'$ ⁴	$B'CD'E$ ⁵	$B'CDE$ ⁷	$B'CDE'$ ⁶
11	$BCD'E'$ ¹²	$BCD'E$ ¹³	$BCDE$ ¹⁵	$BCDE'$ ¹⁴
10	$BC'D'E'$ ⁸	$BC'D'E$ ⁹	$BC'DE$ ¹¹	$BC'DE'$ ¹⁰

A=0

BC \ DE	DE			
	00	01	11	10
00	$B'C'D'E'$ ¹⁶	$B'C'D'E$ ¹⁷	$B'C'DE$ ¹⁹	$B'C'DE'$ ¹⁸
01	$B'CD'E'$ ²⁰	$B'CD'E$ ²¹	$B'CDE$ ²³	$B'CDE'$ ²²
11	$BCD'E'$ ²⁸	$BCD'E$ ²⁹	$BCDE$ ³¹	$BCDE'$ ³⁰
10	$BC'D'E'$ ²⁴	$BC'D'E$ ²⁵	$BC'DE$ ²⁷	$BC'DE'$ ²⁶

A=1

EXAMPLE-1:

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Abdul Rehman

email id:- abdul@northern.edu.pk

Whatsapp#03087792217

5 variable SOP

①

$ABCD\bar{E} + ABCDE + ABCD\bar{E} + ABCDE + ABCDE + ABCDE$

$A = 0$

DE	00	01	11	10
BC	0	1	0	1
00	0	1	0	1
01	0	0	0	0
11	0	0	0	0
10	0	0	0	0

$\bar{B}\bar{C}\bar{E}$

$A = 1$

DE	00	01	11	10
BC	0	1	0	1
00	0	1	0	1
01	0	0	0	0
11	0	0	0	0
10	0	0	0	0

$\bar{A}\bar{C}\bar{E}$

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

EXAMPLE-2:

②

$A = 0$

DE	00	01	11	10
BC	0	0	0	0
00	0	0	0	0
01	0	0	0	0
11	0	0	0	0
10	1	1	1	1

$\bar{A}\bar{B}\bar{C}$

$A = 1$

DE	00	01	11	10
BC	0	0	0	0
00	0	0	0	0
01	0	0	0	0
11	0	0	0	0
10	1	1	1	1

$\bar{A}\bar{B}\bar{C}$

ABCDE	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
1	0	0	0	0	0
1	0	0	0	0	0
1	0	0	0	0	0
1	0	0	0	0	0

ABCDE	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
1	0	0	0	0	0
1	0	0	0	0	0
1	0	0	0	0	0
1	0	0	0	0	0

ABCDE	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
1	0	0	0	0	0
1	0	0	0	0	0
1	0	0	0	0	0
1	0	0	0	0	0

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

POS Through K maps

2 variable POS K map

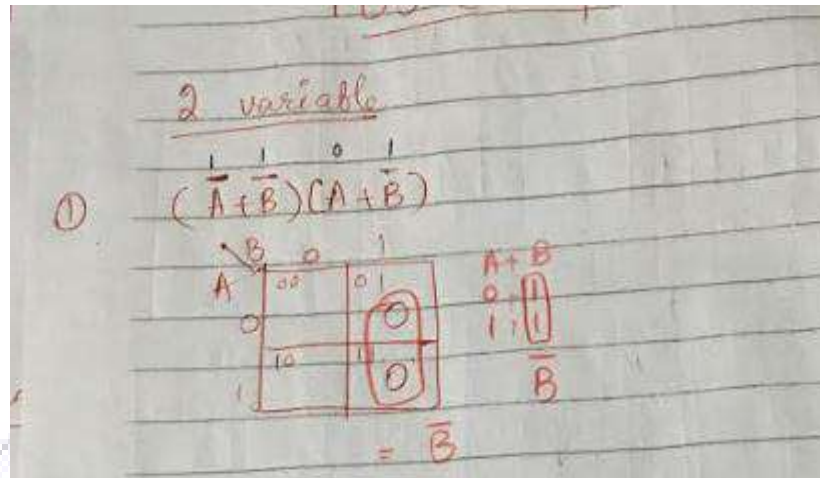
EXAMPLE-1:

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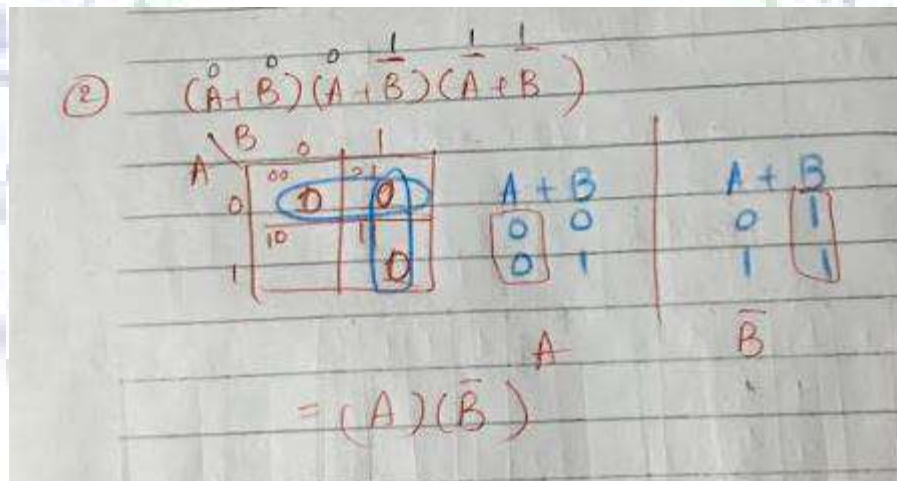
Abdul Rehman

email id:- abdul@northern.edu.pk

Whatsapp#03087792217



EXAMPLE-2:



3 variable POS K map

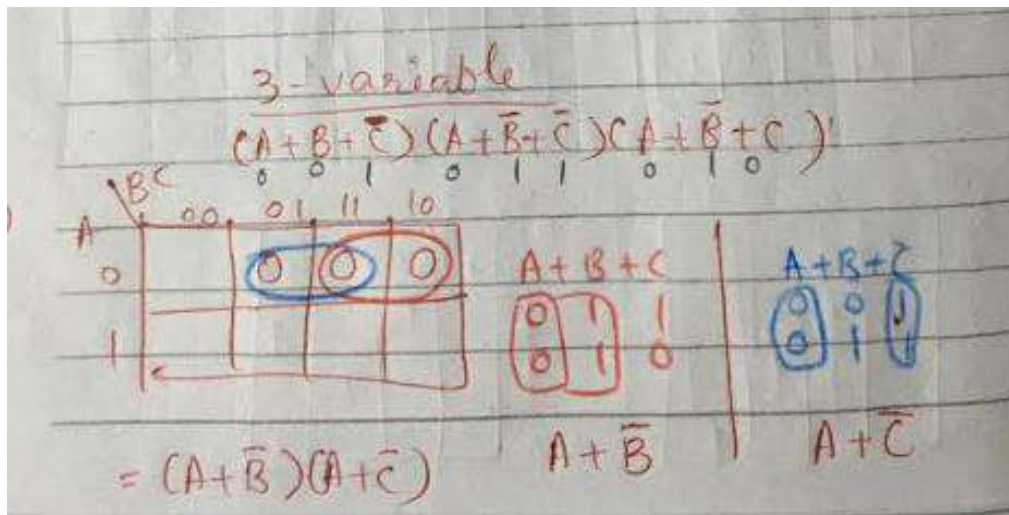
EXAMPLE-1:

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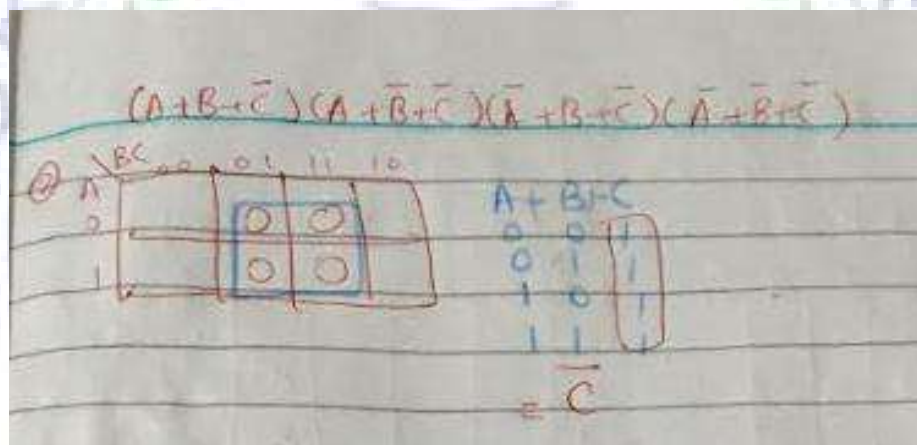
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email id:- abdul@northern.edu.pk

Whatsapp#03087792217



EXAMPLE-2:



4 variable POS Kmap

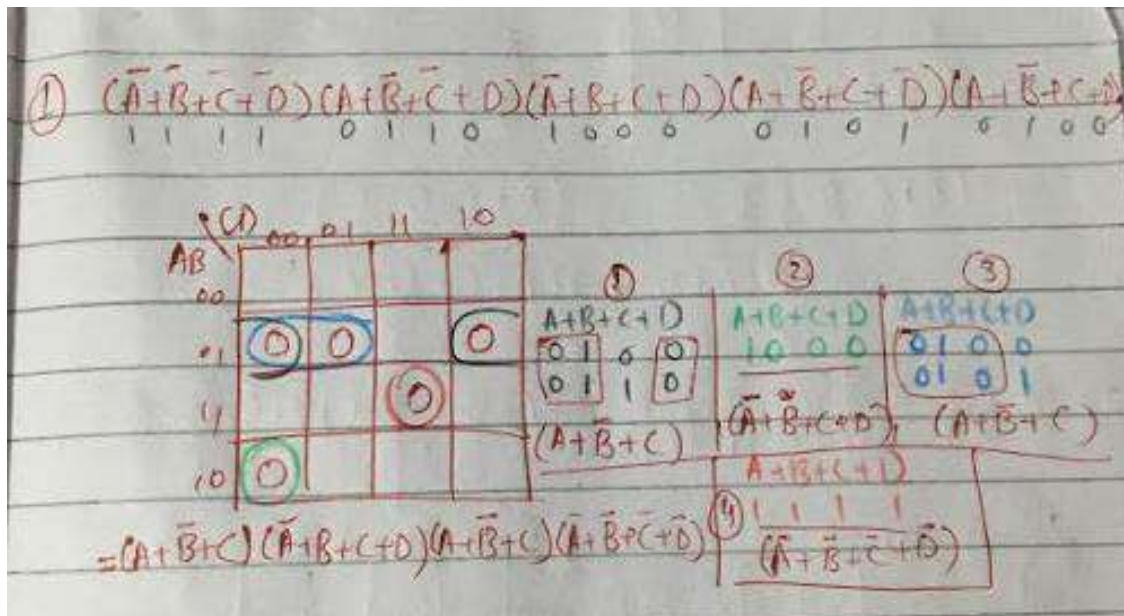
EXAMPLE-1:

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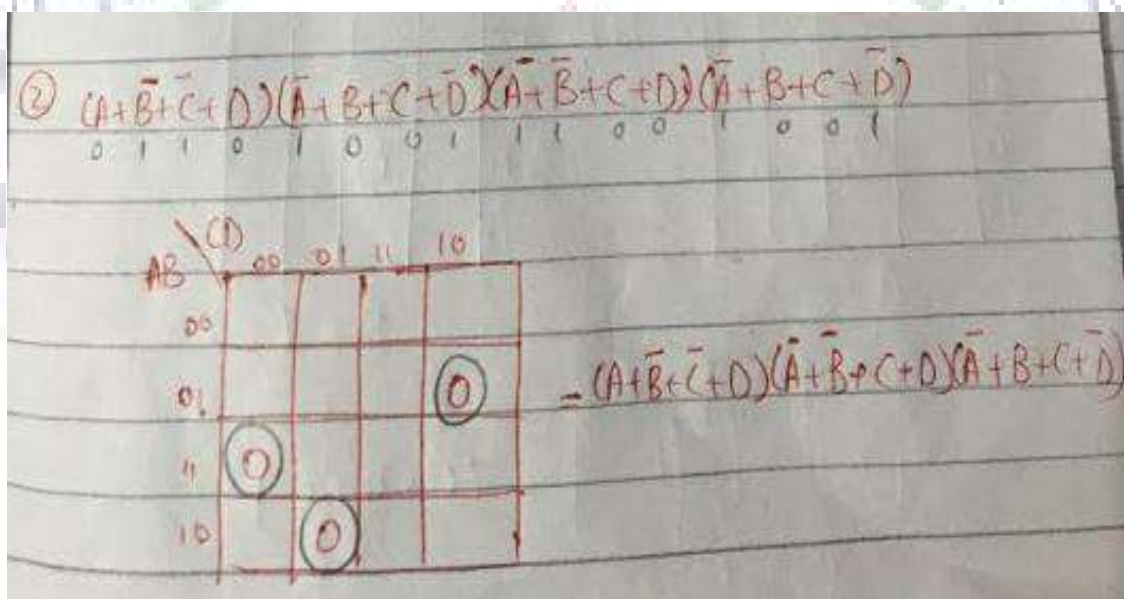
Abdul Rehman

email id:- abdul@northern.edu.pk

Whatsapp#03087792217



EXAMPLE-2:



5 variable POS k map

EXAMPLE-1:

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Abdul Rehman

email id:- abdul@northern.edu.pk

Whatsapp#03087792217

① $(A+B+\bar{C}+D+E)(A+\bar{B}+\bar{C}+D+E)(\bar{A}+B+\bar{C}+D+E)(\bar{A}+\bar{B}+\bar{C}+D+E)$

$A=0$

BC	00	01	11	10
00				
01	0			
11	0			
10				

ABCDE

0	0	1	0	0
0	1	1	0	0

$(A+\bar{C}+D+E)$

$A=1$

BC	00	01	11	10
00				
01				0
11				0
10				

ABCDE

1	0	1	0	
1	1	1	0	

$(\bar{A}+\bar{C}+D+E)$

$= (A+\bar{C}+D+E)(\bar{A}+\bar{C}+D+E)$

EXAMPLE-2:

② $(A+B+\bar{C}+D+\bar{E})(A+\bar{B}+\bar{C}+D+E)(\bar{A}+B+\bar{C}+D+\bar{E})(\bar{A}+\bar{B}+\bar{C}+D+E)$

$A=0$

BC	00	01	11	10
00				
01		0		
11		0		
10				

ABCDE

0	0	1	0	1
0	1	1	0	1
1	0	1	0	1
1	1	1	0	1

$(\bar{C}+D+E)$

$A=1$

BC	00	01	11	10
00				
01		0		
11		0		
10				

ABCDE

1	0	1	0	1
1	1	1	0	1

$(\bar{C}+D+E)$

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

Lecture-12

COMBINATIONAL CIRCUIT DESIGNING

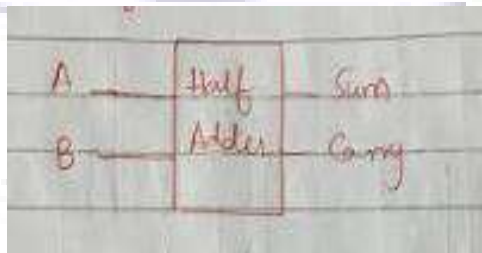
This lecture will teach you to design circuits of your own choice. We will start from mathematical examples, then we will design general purpose components and then we will discuss designing of real life examples

- HALF ADDER
- FULL ADDER
- HALF SUBTRACTOR

EXAMPLE-1:

DESING A HALF ADDER

1. BLOCK DIGRAM:



2. TRUTH TABLE:

A	B	Sum	Carry	Carry into 0	Carry into 1
0	0	0	0	0	0
0	1	1	0	0	0
1	0	1	0	0	0
1	1	0	1	1	1

3. OUTPUT EQUATIONS:

Digital Logic Design (ESC-151)

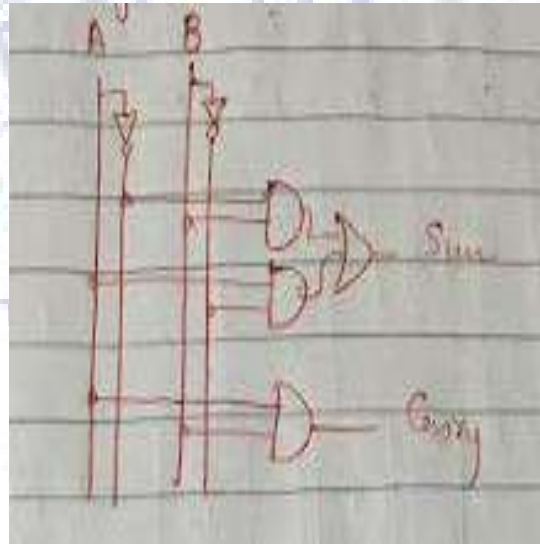
Abdul Rehman

email id:- abdul@northern.edu.pk

Whatsapp#03087792217

$$\begin{aligned} \text{Sum} &= \bar{A}B + A\bar{B} \\ \text{Carry} &= AB \end{aligned}$$

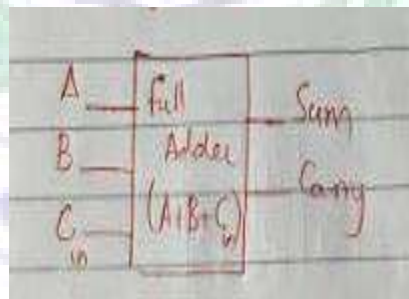
4. CIRCUIT DIAGRAM:



EXAMPLE-2:

DESIGN A FULL ADDER:

1. BLOCK DIAGRAM:



2. TRUTH TABLE:

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email id:- abdul@northern.edu.pk

Whatsapp#03087792217

A	B	C	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

010
+ 101
+ 011
+ 100

1101

00
+ 11
+ 10

10

3. OUTPUT EQUATIONS:

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email id:- abdul@northern.edu.pk

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Output Equation

$$\text{Sum} = \bar{A}\bar{B}C + \bar{A}B\bar{C} + A\bar{B}\bar{C} + ABC$$

$$\text{Carry} = \bar{A}BC + A\bar{B}C + AB\bar{C} + ABC$$

lets simplify them

Sum

BC	00	01	11	10
A				
0	000	001	011	010
		1		1
1	100	101	111	110
	1		1	

no pairs, equation
is already
simplified

$$\text{Sum} = \bar{A}\bar{B}C + \bar{A}B\bar{C} + A\bar{B}\bar{C} + ABC$$

Carry

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

ABC

1	1	1
1	1	0

AB

ABC

0	0	1
1	1	1

AC

ABC

0	1	1
1	1	1

BC

$$\text{Carry} = AB + AC + BC$$

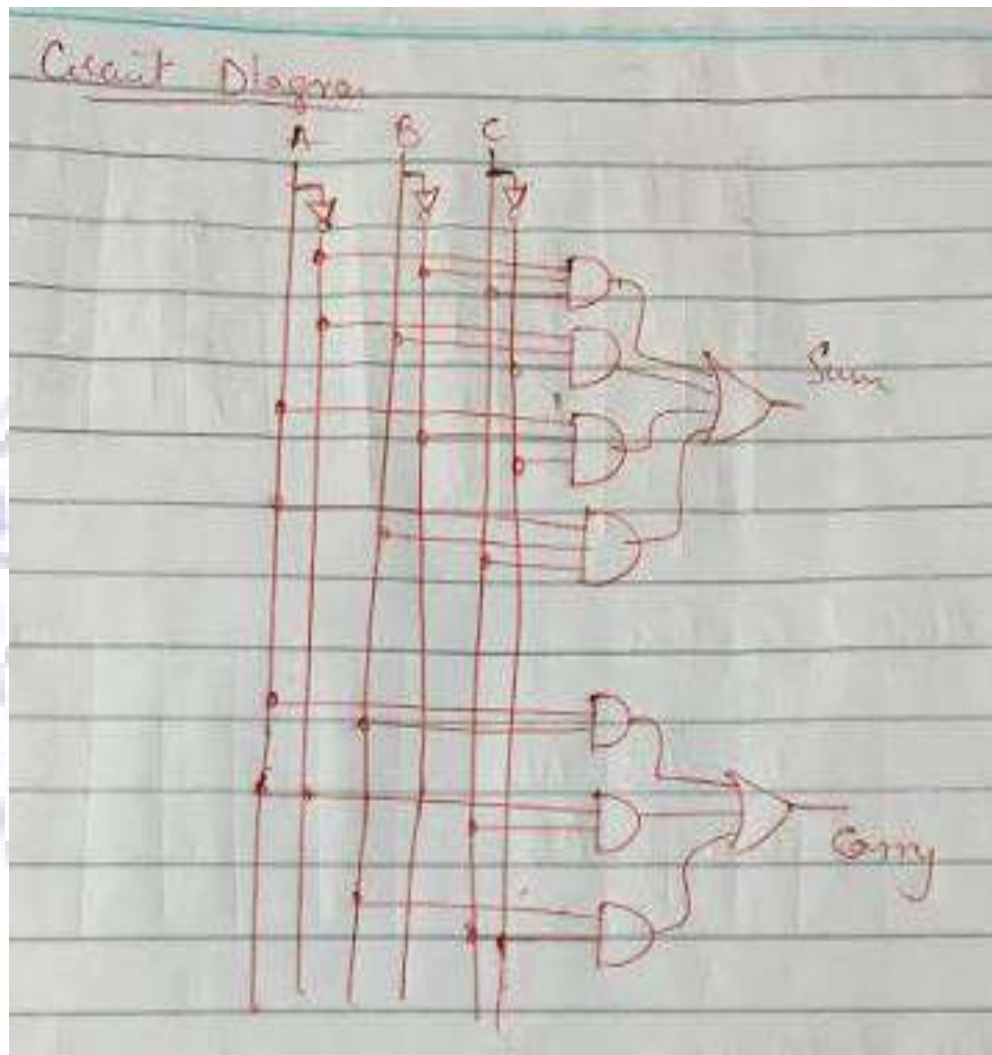
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Abdul Rehman

email id:- abdul@northern.edu.pk

Whatsapp#03087792217

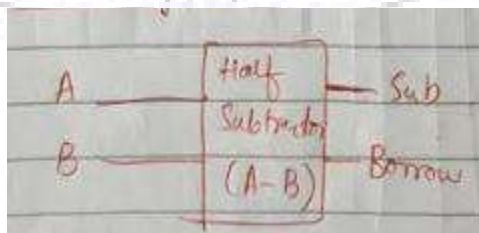
4. CIRCUIT DIAGRAM:



EXAMPLE-3:

DESIGN A HALF SUBTRACTOR:

1. BLOCK DIAGRAM:



2. TRUTH TABLE:

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email id:- abdul@northern.edu.pk

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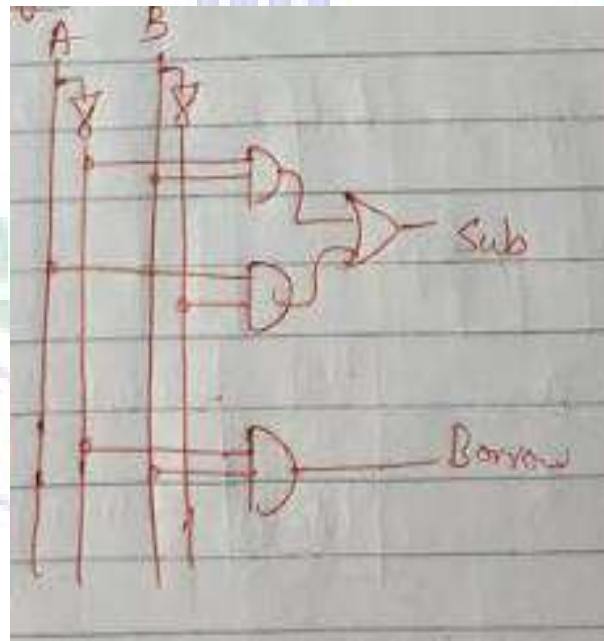
A	B	Sub	Borrow
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

$0 \leftarrow \text{Borrow}$
 -1
 $1 \leftarrow \text{Sub}$

3. OUTPUT EQUATIONS:

$$\text{Sub} = \bar{A}B + A\bar{B}$$
$$\text{Borrow} = \bar{A}B$$

4. CIRCUIT DIAGRAM:



Assignment:6

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Abdul Rehman

email id:- abdul@northern.edu.pk

Whatsapp#03087792217

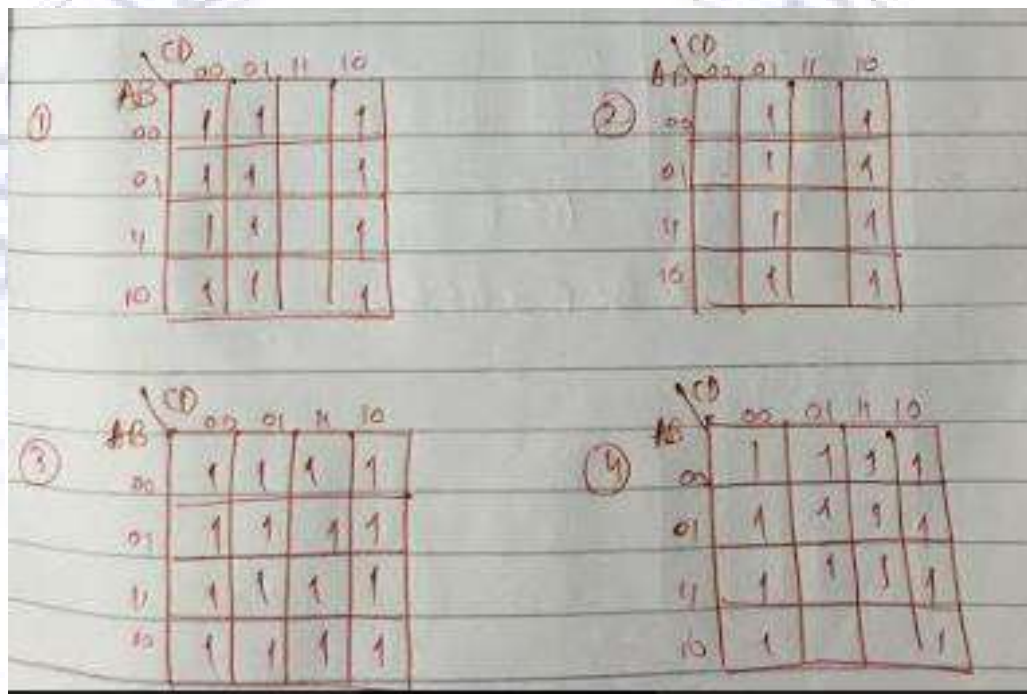
Dear students read the given lectures carefully as per the course objectives mentioned on the top and carryout the assignment as per following instructions

Task to do:

Part-1:

Simplify following K maps and write output equations:

1. 4 variable SOP practice examples:



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

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

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

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

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Abdul Rehman

email id:- abdul@northern.edu.pk

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⑤	AB \ CD		00	01	11	10
	00		1	1	1	
	01		1	1	1	
	11					
	10					

⑧	AB \ CD		00	01	11	10
	00		1	1		
	01		1	1		
	11		1	1	1	1
	10				1	1

2. 5 variable SOP practice examples:

Practice Examples

①

		DE \ BC			
		00	01	11	10
00	BE	1	1	1	1
01			1	1	
11			1	1	
10		1	1	1	1

$$A = 0$$

		DE \ BC			
		00	01	11	10
00	BC	1	1	1	1
01					
11					
10		1	1	1	1

$$A = 1$$

②

		DE \ BC			
		00	01	11	10
00	BC	1			
01		1	1		
11				1	
10					1

		DE \ BC			
		00	01	11	10
00	BC	1			
01			1		1
11				1	
10					1

3. 4 and 5 variable POS practice examples:

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Abdul Rehman

email id:- abdul@northern.edu.pk

Whatsapp#03087792217

①

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

②

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

$A=0$

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

$A=1$

Part-2:

- Design A Full Subtractor

Reference material:

Lesson plans

Text book: Digital design by Moris Mano 4th edition

Also see digital fundamentals 8th ed by Floyd

Lecture Video Links:

Part-1: <https://youtu.be/Nvp1L2Ur6Bw>

Part-2: <https://youtu.be/dVM1oOdRxdc>

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Abdul Rehman

email id:- abdul@northern.edu.pk

Whatsapp#03087792217

Lab Work: <https://youtu.be/CSxHHhJUx9g>

LAB Work:

Design the circuit of Lab-6 on proteus and send its screenshot to Mr Hamza Sakhi via email at hamzasakhic97@gmail.com

Lab manuals have been uploaded on whatsapp and Edmodo library section.

Task Name: Half Subtractor and Full Subtractor

