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## Experiment # 4

### To Understand Minimizing Logical Circuit Techniques

#### Objective:

- *Karnaugh map*
- *Minimizing the digital function*

#### Equipment:

ICs, Digital trainers, Jumpers wires.

#### Theory:

A *Karnaugh map (K-map)* is a pictorial method used to minimize Boolean expressions without having to use Boolean algebra theorems and equation manipulations. Using a K-map, expressions with two to four variables are easily minimized. Expressions with five to six variables are more difficult but achievable, and expressions with seven or more variables are extremely difficult (if not impossible) to minimize using a K-map.

- *Minimizing Logical Circuits (Karnaugh maps)*

**Note:** When entering values, please use the following symbols:

FUNCTION	SYMBOL
OR	$\vee$ , +
AND	$\cdot$
NOT	'

## Exercise 1:

Karnaugh map K1

		<b>A</b>		<b>B</b>
×	B'A'	B'A	BA	BA'
D'C'	1	0	0	1
D'C	0	0	0	0
DC	0	0	0	0
DC'	1	0	0	1

Given the Karnaugh map K1 =  $\underline{D'C'(B'A'+BA')} + DC'(B'A'+BA')} = \underline{C'A'}$  Answer:

## Exercise 2:

Karnaugh map K2

		<b>A</b>		<b>B</b>
×	B'A'	B'A	BA	BA'
D'C'	0	1	1	1
D'C	1	1	1	1
DC	0	1	1	0
DC'	0	1	1	0

Given the Karnaugh map K2 =  $\underline{1(B'A+BA)} + \underline{1(D'C)} + \underline{D'(BA+BA')} = \underline{A} + \underline{D'C} + \underline{D'B}$  Answer:

### Exercise 3:

Table 1

	C	B	A	Q
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	0
7	1	1	1	1

Karnaugh map K3

×	B'A'	B'A	BA	BA'
C'			1	
C		1	1	

Column Rectangle: =  $(C' + C)(BA) = BA$

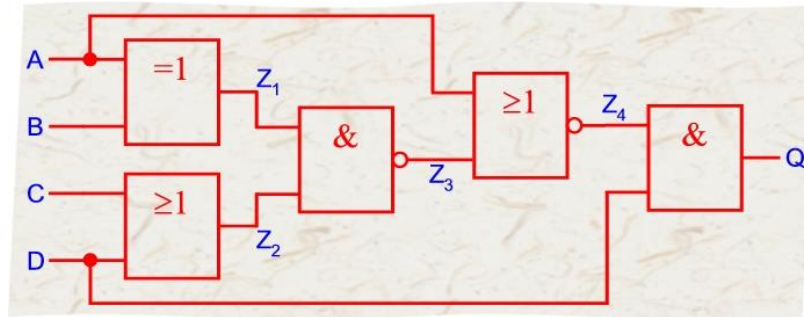
Row Rectangle: =  $C(B'A + BA) = CA$

Answer =  $BA + CA$

- Q 4.1 What is the minimized function for the output Q?

Ans: The minimized function for the output Q =  $BA + CA$  Answer

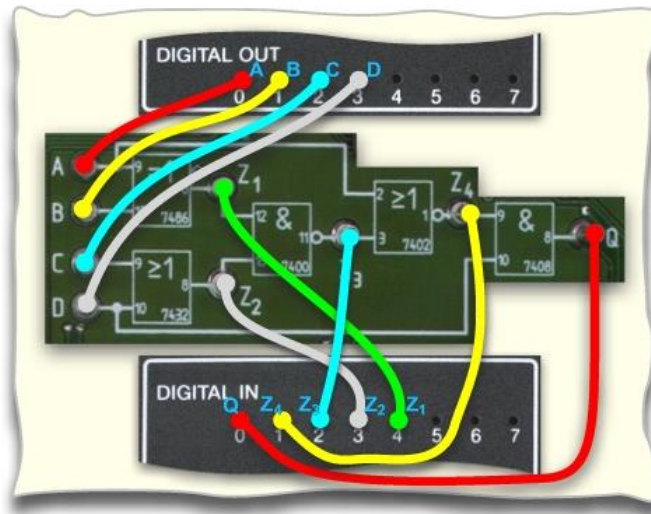
### Sequence of gates



*Circuit diagram of the sequence of gates to be investigated*

In this experiment, we investigate the sequence of gates and attempt to minimize the sequence

#### **Exercise 4:**



*Fig.1 : Experiment set-up, - Sequence of gates*

**Table 1**

	$Q_3$	$Q_2$	$Q_1$	$Q_0$	$I_4$	$I_3$	$I_2$	$I_1$	$I_0$
	D	C	B	A	Z <sub>1</sub>	Z <sub>2</sub>	Z <sub>3</sub>	Z <sub>4</sub>	Q
0	0	0	0	0	0	0	0	0	0
1	0	0	0	1	1	0	0	1	0
2	0	0	1	0	1	0	0	0	0
3	0	0	1	1	0	0	0	1	0
4	0	1	0	0	0	1	0	0	0
5	0	1	0	1	1	1	1	1	0
6	0	1	1	0	1	1	1	1	0
7	0	1	1	1	0	1	0	1	0
8	1	0	0	0	0	1	0	0	0
9	1	0	0	1	1	1	1	1	1
10	1	0	1	0	1	1	1	1	1
11	1	0	1	1	0	1	0	1	1
12	1	1	0	0	0	1	0	0	0
13	1	1	0	1	1	1	1	1	1
14	1	1	1	0	1	1	1	1	1
15	1	1	1	1	0	1	0	1	1

### Karnaugh map 1

Output: Q

<b>B</b>	0	0	1	1	
<b>A</b>	0	1	1	0	
		1	1	1	0
		1	1	1	1
					1
					0
					0
					0
					<b>C</b>
					<b>D</b>

- Q 4.2 What is the minimized function for this sequence of gates?

Ans: The minimized function for this sequence of gates  $Q = DA + DB$  Answer

**Exercise 5:** Implement the minimized function and complete the following truth table.

Table 2

	<b>D</b>	<b>B</b>	<b>A</b>	<b>Q</b>
0	0	0	0	0
1	0	0	1	0
2	0	1	0	0
3	0	1	1	0
4	1	0	0	0
5	1	0	1	1
6	1	1	0	1
7	1	1	1	1

### Exercise 6:

Enter the values for  $Z_4$  from *Table 1* into Karnaugh map 2 and determine the minimized function for  $Z_4$ .

### *Karnaugh map 2*

Output:  $\mathbf{Z}_4$

**B**

**A**

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

**C** **D**

*Note:*

*The small numerals correspond to the line numbers from Table 1<. They are intended to make it clearer where everything belongs.*

- Q 4.4 What is the minimized function for  $Z_4$ ?

Ans: The minimized function for  $Z_4 = A + DB + CB$  Answer

Enter the values for  $Z_3$  from *Table 1* into Karnaugh map 2 and determine the minimized function for  $Z_3$ .

*Karnaugh map 3*

Output:  $\mathbf{Z}_3$

**B** 0 0 1 1

**A** 0 1 1 0

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

**C** **D**

*Note:*

*The small numerals correspond to the line numbers from Table 1. They are intended to make it clearer where everything belongs.*

- Q 4.5 What is the minimized function for  $Z_3$ ?

Ans: The minimized function for Z3=  $DAB' + \cancel{DA'B} + CAB' + CA'B$  Answer