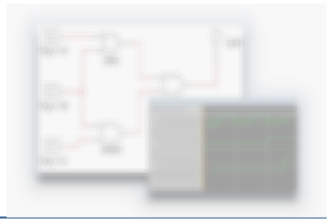


ECE119 – Ψηφιακή Σχεδίαση

Διδάσκοντες Εργαστηρίου: Δ. Καραμπερόπουλος
Α. Φεύγας

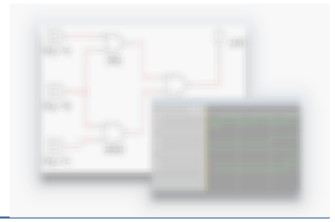
- Lab 4: Karnaugh Maps

Περιεχόμενα Εργαστηριακού Μαθήματος



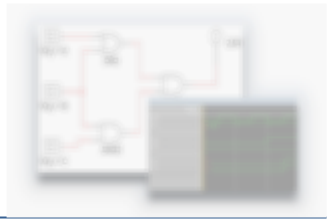
- Εισαγωγή
- Lab 1: Multisim Circuit Simulation and Basic Gates
- Lab 2: Truth Tables and Basic Logic Gates
- Lab 3: Logic Gates Explored and Boolean Algebra
- **Lab 4: Karnaugh Maps**
- Lab 5: Binary Conversion and Adders
- Lab 6: Encoders and Decoders
- Lab 7: Multiplexers and Demultiplexers
- Lab 8: Latches and Sequential Logic Circuits
- Lab 9: Flip-Flops
- Lab 10: Sequential Circuits – FSM (1ο)
- Lab 11: Sequential Circuits – FSM (2ο)

Karnaugh Maps



- The **Karnaugh map (K-map)** is a tool and procedure used **for minimizing Boolean functions**.
- It is a graphical method that can be used for the manual design of simple logic functions having a small number of variables.
- K-mapping usually requires fewer steps than algebraic simplification and it always produces a minimum expression.
- The Karnaugh map of a function is actually its truth table written as a grid. The rows and the columns of the map correspond to the possible values of the inputs and each cell represents the outputs of the function for the correlated inputs.

Karnaugh Maps

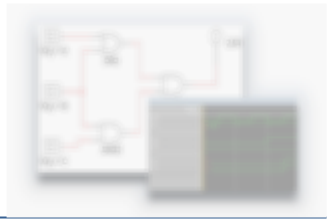


- The simplified expressions are always in one of the two standard forms:
  - Sum-of-Products
  - Product-of-Sums
- The cells are formed in a square or rectangle fashion and arranged such that neighboring cells have a single variable difference, otherwise known as Gray code ordering. For simplicity, the input values are placed as column and row labels. Each cell corresponds to a row in the truth table.

A	B	C	O
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

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

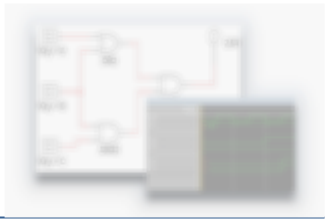
Learning Objectives



In this lab, students will:

- Simplify a Boolean expression using Karnaugh maps
- Use a circuit with inputs to derive:
  - The output experimentally and using Boolean algebra
  - The Karnaugh map
  - Simplified Combinational Logic Circuit

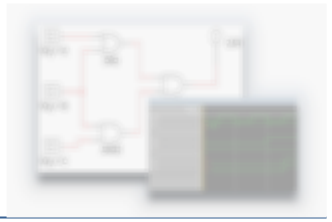
Expected Deliverables



In this lab, you will collect the following deliverables:

- Boolean expressions
- Analysis of gates for Combinational Logic Circuits
- Truth tables
- Conclusion questions

Karnaugh Maps



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

SOP (1's): AC + A'D' + B'D'

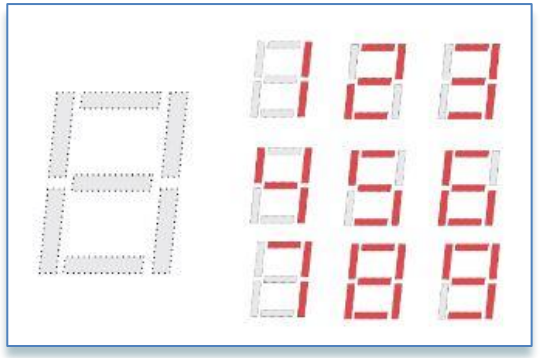
Kmap Colour

POS (0's): (A+D') (C+D') (A'+B'+C)

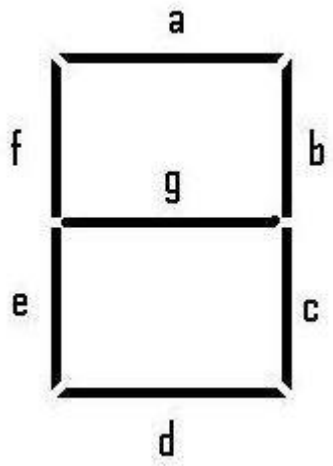
Kmap Colour

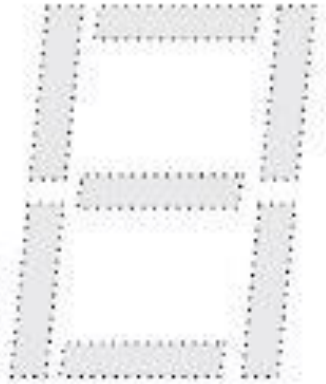
Seven Segment Display

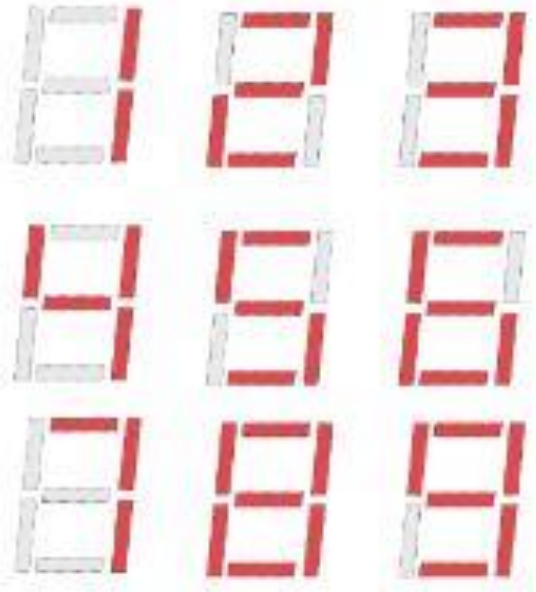
- Karnaugh maps are useful for **minimizing the number of logic gates** needed in a circuit. In a practical sense, this reduction also results in a decrease in cost for a manufacturer since fewer components are needed to create an equivalent circuit.
- A common way we work with Karnaugh maps is the **Seven Segment Display (SSD)**.
- An SSD is an electronic device used for displaying numerical values. The device typically consists of seven segments arranged in a figure 8. Any digit, as well as some alphabet letters, can be displayed when the correct segments are activated. An example of an SSD as well as possible outputs can be seen in the image shown.



Seven Segment Display



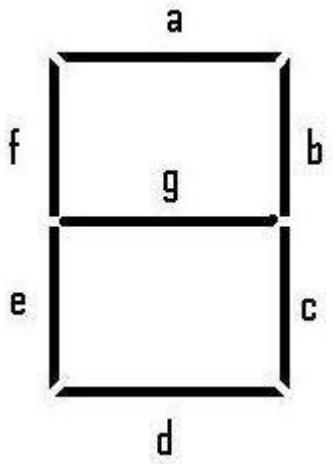


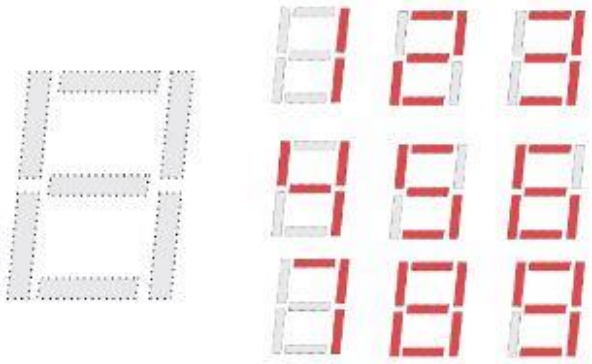


Seven Segment Display

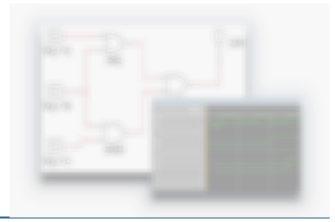
- The **truth table** for an SSD consists of four inputs and seven outputs:

A	B	C	D	a	b	c	d	e	f	g	Numeric Output
0	0	0	0	1	1	1	1	1	1	0	0
0	0	0	1	0	1	1	0	0	0	0	1
0	0	1	0	1	1	0	1	1	0	1	2
0	0	1	1	1	1	1	1	0	0	1	3
0	1	0	0	0	1	1	0	0	1	1	4
0	1	0	1	1	0	1	1	0	1	1	5
0	1	1	0	1	0	1	1	1	1	1	6
0	1	1	1	1	1	1	0	0	0	0	7
1	0	0	0	1	1	1	1	1	1	1	8
1	0	0	1	1	1	1	1	0	1	1	9
1	0	1	0	X	X	X	X	X	X	X	10
1	0	1	1	X	X	X	X	X	X	X	11
1	1	0	0	X	X	X	X	X	X	X	12
1	1	0	1	X	X	X	X	X	X	X	13
1	1	1	0	X	X	X	X	X	X	X	14
1	1	1	1	X	X	X	X	X	X	X	15





Seven Segment Display



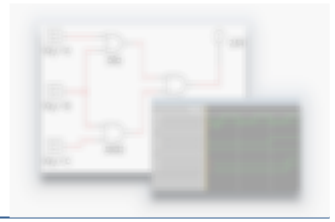
- The numerical outputs of 0-9 are necessary in an SSD, but outputs 10-15 are said to be illegal.
- In a Karnaugh map, don't care conditions can be treated either as 0 or a 1, depending on which one produces a larger block. See below for an example.

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

Karnaugh Map for output "a"

- Note: Similar Karnaugh maps can be created for all other segments.

Παράδειγμα



Prime implicants
(Πρωτεύοντες Όροι)

- ***A'D***
- ***BD'***
- ***A'B***

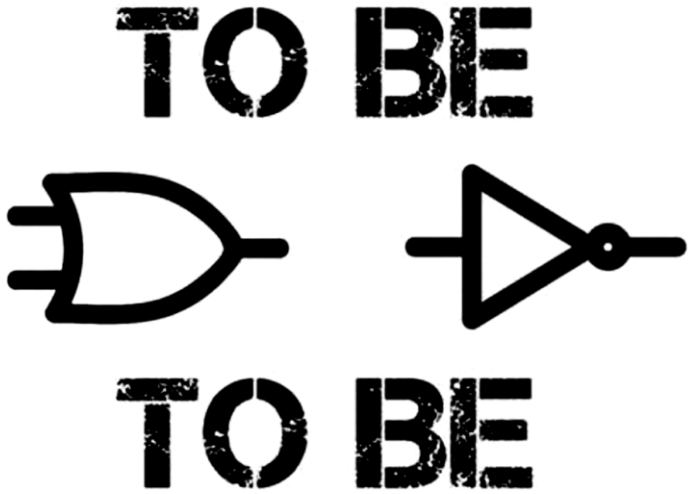
Essential Prime implicants
Ουσιώδεις Πρωτεύοντες Όροι

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

F = A'D + BD'

Ευχαριστώ για την προσοχή σας!

- **Ερωτήσεις / Απορίες ;**



Επικοινωνία: ece119.uth@gmail.com