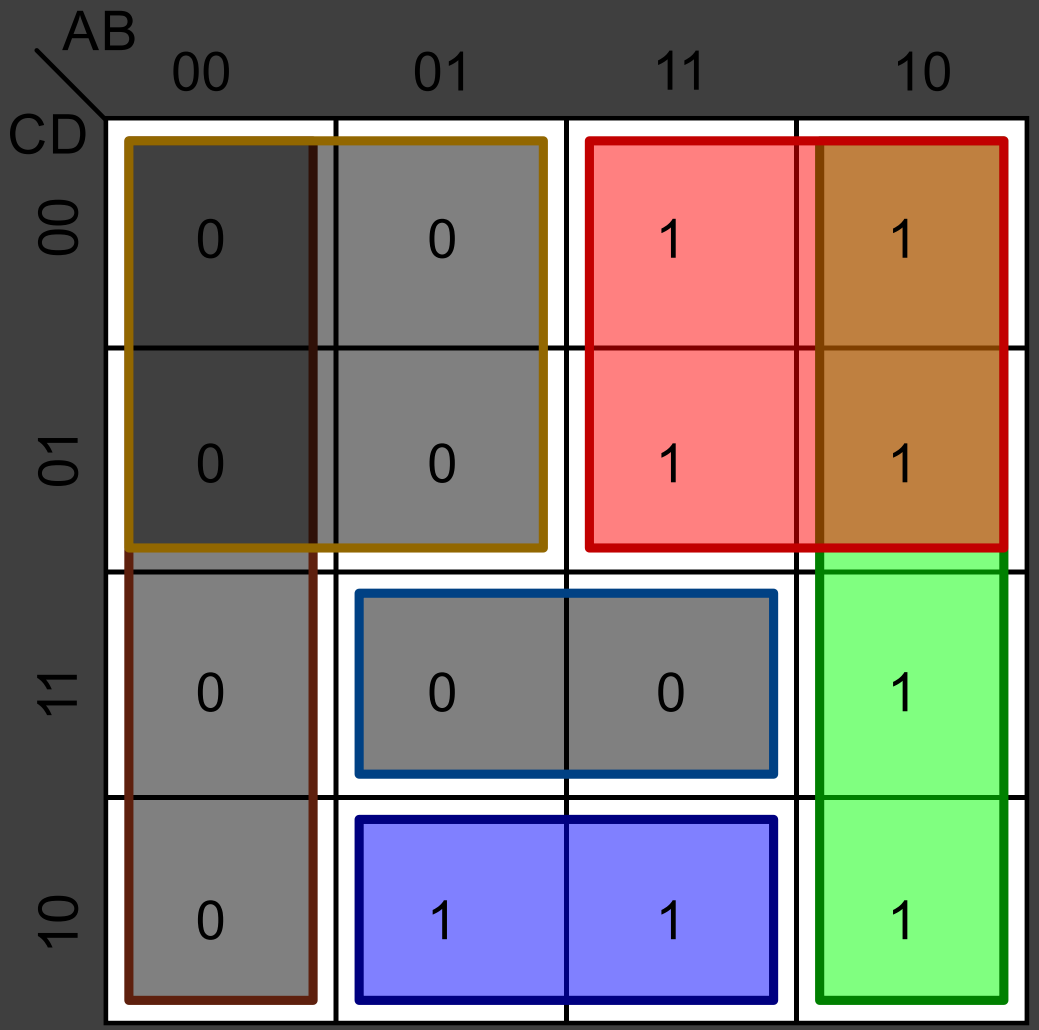
# ECE213: Digital Electronics

Ajmer Singh
9988921373
ajmer.17381@lpu.co.in

# The Course Contents

## Unit II

Combinational Logic System : Truth table, Basic logic operation, Boolean Algebra, Basic postulates, Standard representation of logic functions -SOP forms, Simplification of switching functions - K-map, Synthesis of combinational logic circuits, Logic gates, Fundamental theorems of Boolean algebra, Standard representation of logic functions POS forms

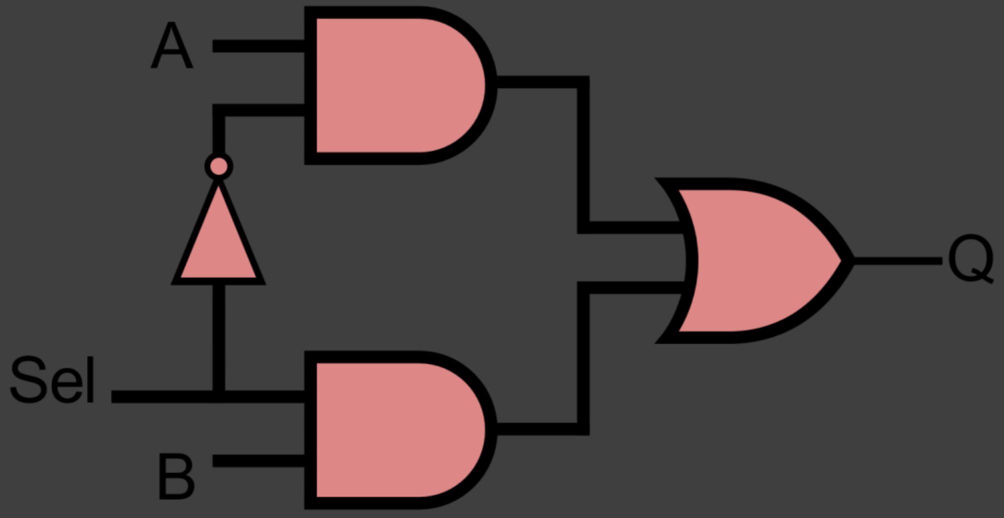


# The Course Contents

## Unit III

Introduction to Combinational Logic Circuits : Adders, Subtractors, Comparators, Multiplexers and Demultiplexers, Decoders, Encoders, Parity circuits

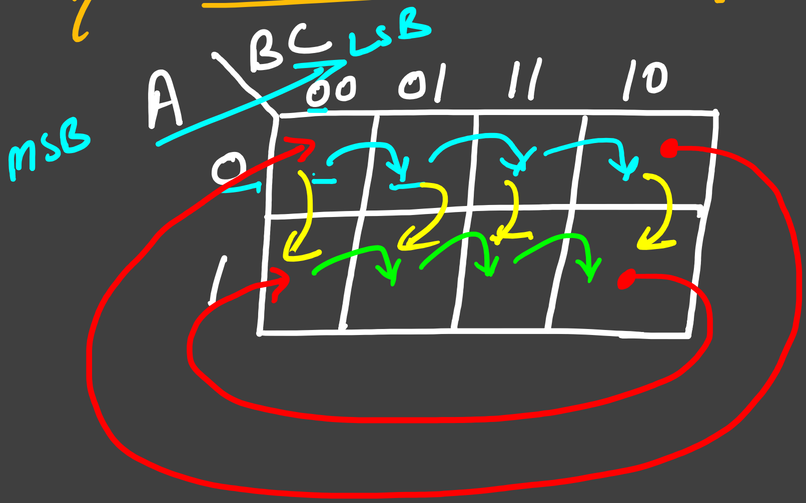
Introduction to Logic Families : Introduction to different logic families, Structure and operations of TTL, MOS and CMOS logic families



# Combinational Logic System

## Simplification of switching functions – Karnaugh-map

### 3 – Var K – map




MSB → LSB

| A \ BC | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | 0 000 | 1 001 | 3 011 | 2 010 |
| 1 | 4 100 | 5 101 | 7 111 | 6 110 |

Cell numbe

# Combinational Logic System

## Simplification of switching functions - K-map

| | |
|---|---|
| 2-Var | 0–3 |
| 3-Var | 0–7 |
| 4-Var | 0–15 |
| 5-Var | 0–31 |
| 6-Var | 0–63 |

Ex Reduce the following Boolean fun. using K-map

$$Y = \sum m(0,1,2,5,6)$$

| A \ BC | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | 1 (0) | 1 (1) | (3) | 1 (2) |
| 1 | (4) | 1 (5) | (7) | 1 (6) |

overlapping

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

$$Y = (B \oplus C) + \bar{A}\bar{B}$$

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

wrap around

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

$$Y = (B \oplus C) + \bar{A}\bar{C}$$

# Combinational Logic System

## Simplification of switching functions - K-map

$Y_1$

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

$$Y_1 = \overline{B}$$

$Y_3$

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

$$Y_3 = B$$

$Y_5$

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

$$Y_5 = \overline{C}$$

$Y_2$

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

$$Y_2 = C$$

$Y_4$

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

$$Y_4 = \overline{A} + \overline{B}\,\overline{C}$$

Q: How many variable can be elimitate using $2^n$ group size in Kmap

A: $n=0$ $\quad 2^0=1$

$n=1$ $\quad 2^1=2$ ← n-var

$n=2$ $\quad 2^2=4$

$n=3$ $\quad 2^3=8$

# Combinational Logic System

## Simplification of switching functions - K-map

$Y_6$

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

$$Y_6 = C + B$$

$Y_8$

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

$$Y_8 = \bar{B}C + B\bar{C} + AC$$

$Y_{10}$

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

$$Y_{10} = \bar{A}C + AB$$

$Y_7$

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

$$Y_7 = A + \bar{C}$$

$Y_9$

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

$$Y_9 = C + \bar{A}\bar{B} + AB$$

$Y_{11}$

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

$$Y_{11} = B + \bar{A}\bar{C}$$

# Combinational Logic System

## Simplification of switching functions - K-map

**Ex**

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

$$Y = \bar{A}\bar{B}C + \bar{A}B\bar{C} + A\bar{B}\bar{C} + ABC$$

$$= \bar{A}(\bar{B}C + B\bar{C}) + A(\bar{B}\bar{C} + BC)$$

$$= \bar{A}\,(B \oplus C) + A(\overline{B \oplus C})$$

$$= A \oplus B \oplus C$$

X

| A \ B | 0 | 1 |
|---|---|---|
| 0 | 0 | 1 |
| 1 | 1 | 0 |

$$X = A \oplus B$$

Z

| A \ B | 0 | 1 |
|---|---|---|
| 0 | 1 | 0 |
| 1 | 0 | 1 |

$$Z = \overline{A \oplus B}$$

Y

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

$$Y = \bar{B}(A \oplus C) + B(\overline{A \oplus C})$$

$$= A \oplus B \oplus C$$

# Combinational Logic System

## Simplification of switching functions - K-map

Ex

| $A \backslash BC$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | 1 | 0 | 1 | 0 |
| 1 | 0 | 1 | 0 | 1 |

$$Y = \bar{A}\bar{B}\bar{C} + A\bar{B}C + \bar{A}BC + AB\bar{C}$$

$$= \bar{B}(\bar{A}\bar{C} + AC) + B(\bar{A}C + A\bar{C})$$

$$= \bar{B}(\overline{A \oplus C}) + B(A \oplus C)$$

$$= A \oplus B \oplus C$$

Unit 3

# Combinational Logic System

## Simplification of switching functions - Karnaugh-map

**Ex** Design and implement the full adder ckt.

**Ans** Logic: It can add two 1-bit binary number, considering previous carry

| | A | B | $C_{in}$ | S | $C_{out}$ |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 1 | 1 | 0 |
| 2 | 0 | 1 | 0 | 1 | 0 |
| 3 | 0 | 1 | 1 | 0 | 1 |
| 4 | 1 | 0 | 0 | 1 | 0 |
| 5 | 1 | 0 | 1 | 0 | 1 |
| 6 | 1 | 1 | 0 | 0 | 1 |
| 7 | 1 | 1 | 1 | 1 | 1 |

for Sum S

| A \ B $C_{in}$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | 0 | 1 | 0 | 1 |
| 1 | 1 | 0 | 1 | 0 |

$$S = A \oplus B \oplus C_{in}$$

For Carry

| A \ B $C_{in}$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 0 |
| 1 | 0 | 1 | 1 | 1 |

$$Y = AC_{in} + BC_{in} + AB$$

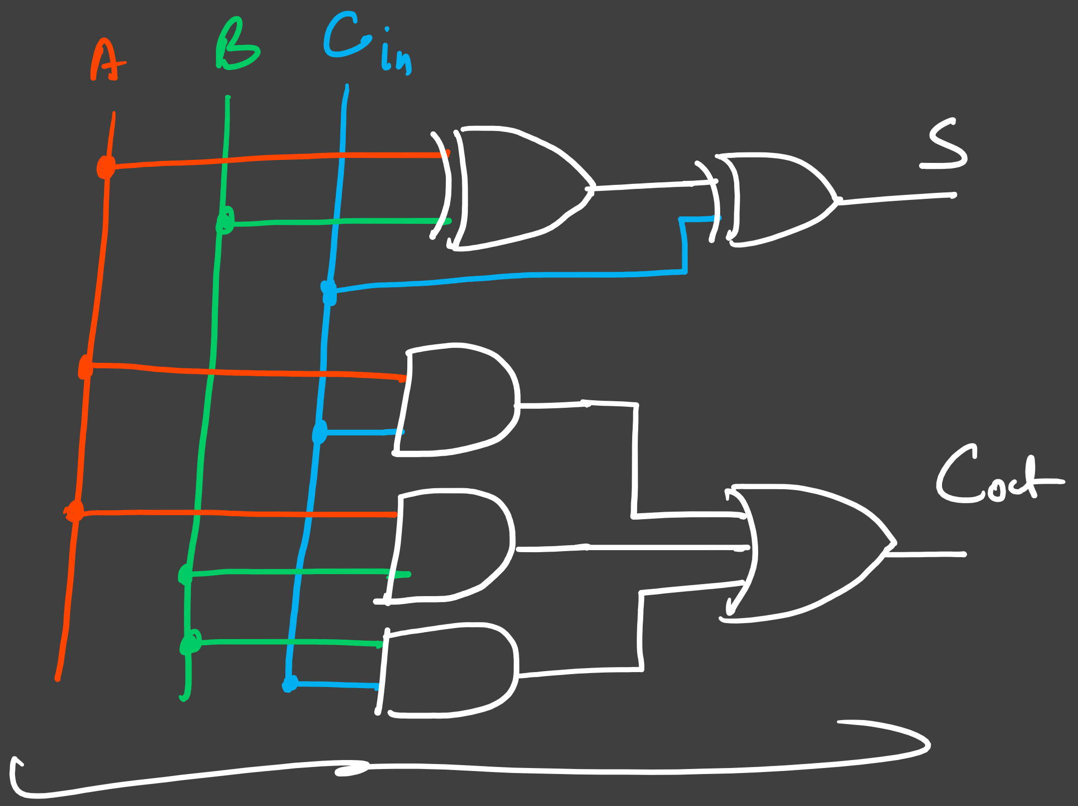
Or for carry

| A \ B $C_{in}$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 0 |
| 1 | 0 | 1 | 1 | 1 |

$$Y = (A \oplus B) C_{in} + AB$$

# Combinational Logic System

## Simplification of switching functions - K-map




full adder.

# Combinational Logic System

Unit 3

## Simplification of switching functions – K-map

**Ex** Design and implement the full subtractor

**Ans** Logic: It can subtract two 1-bit binary number considering previous Borrow.

| A | B | Bin | D | Bout |
|---|---|---|---|---|
| 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 |

# for D

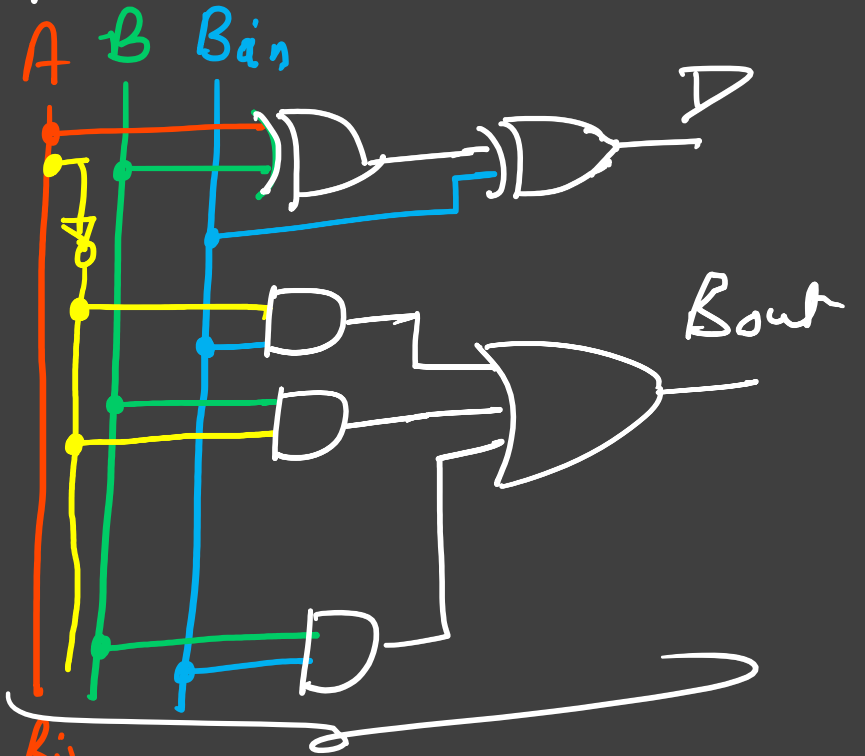
| A \ B Bin | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | 0 | 1 | 0 | 1 |
| 1 | 1 | 0 | 1 | 0 |

$$D = A \oplus B \oplus B_{in}$$

# Bout

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

$$B_{out} = \bar{A} B_{in} + \bar{A} B + B B_{in}$$




full subtract

# Combinational Logic System

## Simplification of switching functions – K-map

### 4-Var K-map

MSB LSB

| AB \ CD | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 0<br>0000 | 1<br>0001 | 3<br>0011 | 2<br>0010 |
| 01 | 4<br>0100 | 5<br>0101 | 7<br>0111 | 6<br>0110 |
| 11 | 12<br>1100 | 13<br>1101 | 15<br>1111 | 14<br>1110 |
| 10 | 8<br>1000 | 9<br>1001 | 11<br>1011 | 10<br>1010 |

1-bit

1-bit

- Possible Group size in 4-Var K-map
- 1 Cell, 2 Cell, 4 Cell, 8 Cell, 16 Cell.

Ex

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

$$Y = BD + AC + \bar{A}\bar{B}\bar{C}$$

# Combinational Logic System

## Simplification of switching functions - K-map

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

$$Y_1 = BD + A\bar{B} + \bar{B}\,\bar{D}$$

$$= \overline{B \oplus D} + A\bar{B}$$

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

$$Y_2 = \bar{B}\,\bar{C} + \bar{A}BD + ABC$$

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

$$Y = \bar{C}\,\bar{D} + ABD + \bar{A}CD$$

# Combinational Logic System

## Simplification of switching functions – K-map

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

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

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

# Combinational Logic System

## Simplification of switching functions - K-map

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

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

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

# Combinational Logic System

## Simplification of switching functions – K-map

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

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

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