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ONLINE LEARNING

# Digital Electronics (SKEE1223)

## Combinational Logic Networks

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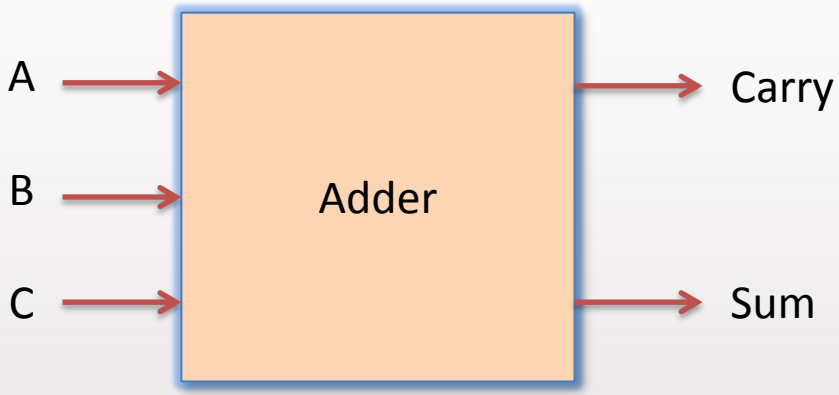
# Adder Design using NANDs Only




| A | B | C | Carry | Sum |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 | 1 |
| 0 | 1 | 0 | 0 | 1 |
| 0 | 1 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 | 1 |
| 1 | 0 | 1 | 1 | 0 |
| 1 | 1 | 0 | 1 | 0 |
| 1 | 1 | 1 | 1 | 1 |

# Adder Equations

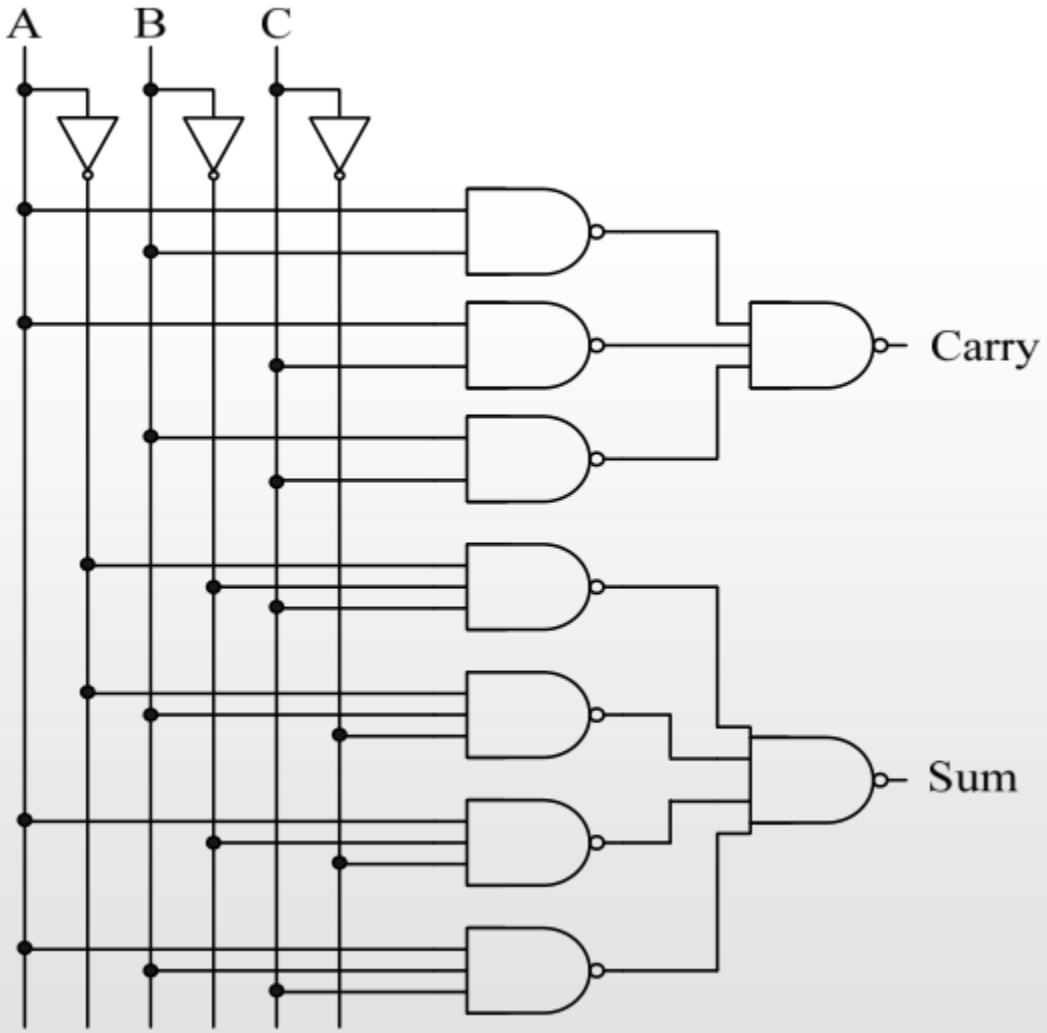
| A \ BC | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 0 |
| 1 | 0 | 1 | 1 | 1 |

$$Carry = A.B + A.C + B.C$$

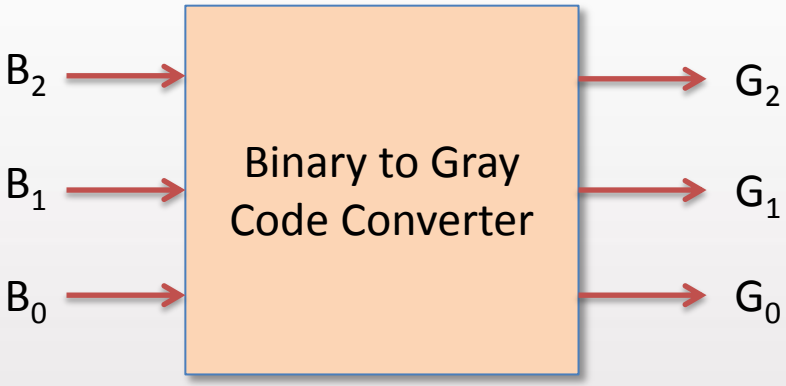
| A \ BC | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | 0 | 1 | 0 | 1 |
| 1 | 1 | 0 | 1 | 0 |

$$Sum = \overline{A}.\overline{B}.C + \overline{A}.B.\overline{C} + A.\overline{B}.\overline{C} + A.B.C$$

# Adder Circuit



# Binary to Gray Code Converter




| $B_2$ | $B_1$ | $B_0$ | $G_2$ | $G_1$ | $G_0$ |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 | 0 | 1 |
| 0 | 1 | 0 | 0 | 1 | 1 |
| 0 | 1 | 1 | 0 | 1 | 0 |
| 1 | 0 | 0 | 1 | 1 | 0 |
| 1 | 0 | 1 | 1 | 1 | 1 |
| 1 | 1 | 0 | 1 | 0 | 1 |
| 1 | 1 | 1 | 1 | 0 | 0 |

# Converter Equations

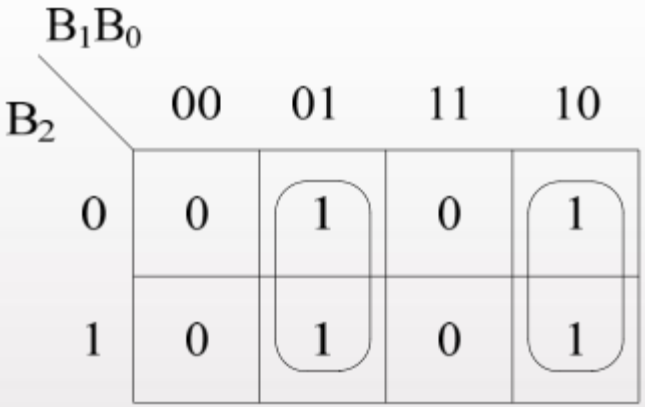
| $B_2$ \ $B_1B_0$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 | 1 |

$$G_2 = B_2$$

| $B_2$ \ $B_1B_0$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 1 |
| 1 | 1 | 1 | 0 | 0 |

$$G_1 = \overline{B_2}.B_1 + B_2.\overline{B_1} = B_2 \oplus B_1$$

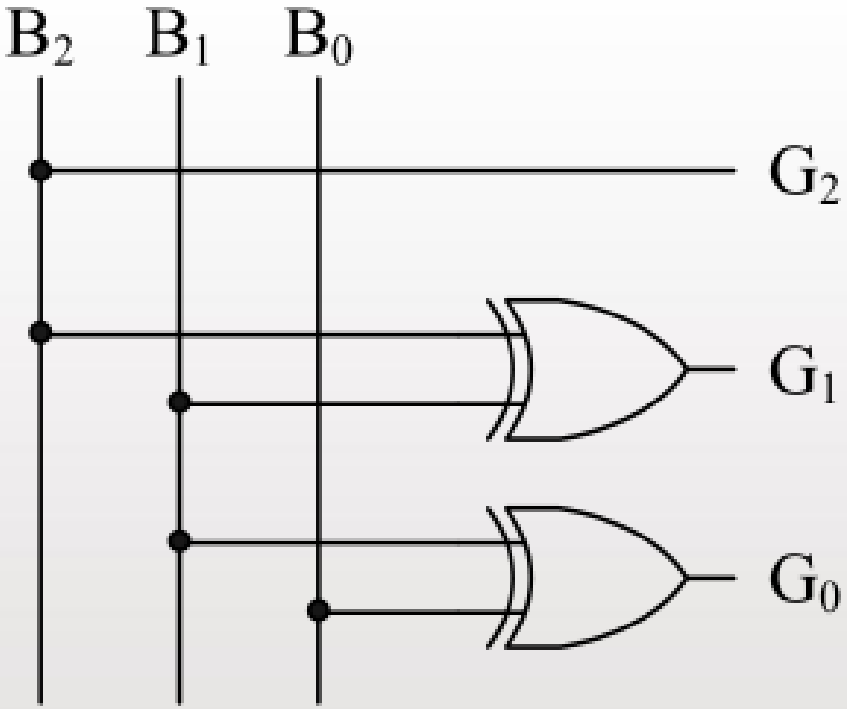
# Converter Equations



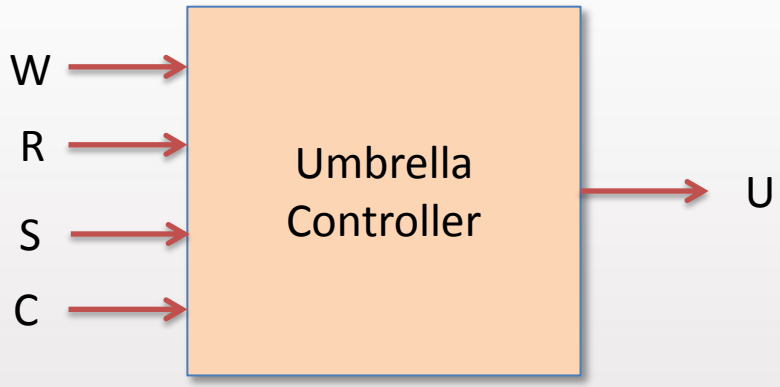
| $B_2$ \ $B_1B_0$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | 0 | 1 | 0 | 1 |
| 1 | 0 | 1 | 0 | 1 |

$$G_0 = \overline{B_1}.B_0 + B_1.\overline{B_0} = B_1 \oplus B_0$$

# Converter Circuit



# Umbrella Controller




- A restaurant wants a smart umbrella system for its outdoor tables. It comprises of four sensors for
  - wind (W)
  - rain (R)
  - direct sunlight (S)
  - the presence of customers (C).

# Umbrella Sensor Specifications

| Sensor | Conditions |
|---|---|
| W | 0 if wind speed is less than 40 km/h |
| | 1 if wind speed is greater than 40 km/h |
| R | 0 if no rain detected |
| | 1 if it is raining |
| S | 0 if there is no direct sunlight |
| | 1 if there is a direct sunlight |
| C | 0 if there is no customer |
| | 1 if one or more customers are presen |

# Umbrella Controller Specifications

| The umbrella is to open when: | |
|---|---|
| I | If it is raining and the wind speed is less than 40 km/h, with or without any customers |
| II | If direct sunlight is detected when one or more customers are present at the table |
| III | If it is raining and the wind speed is greater than 40 km/h, with the presence of one or more customers |

# Umbrella Controller SOP Equation

- Task: Design and implement the system in NOR-NOR configuration.
- Based on the given info, the equation for U is

$$U = \overline{W}.R + S.C + W.R.C$$

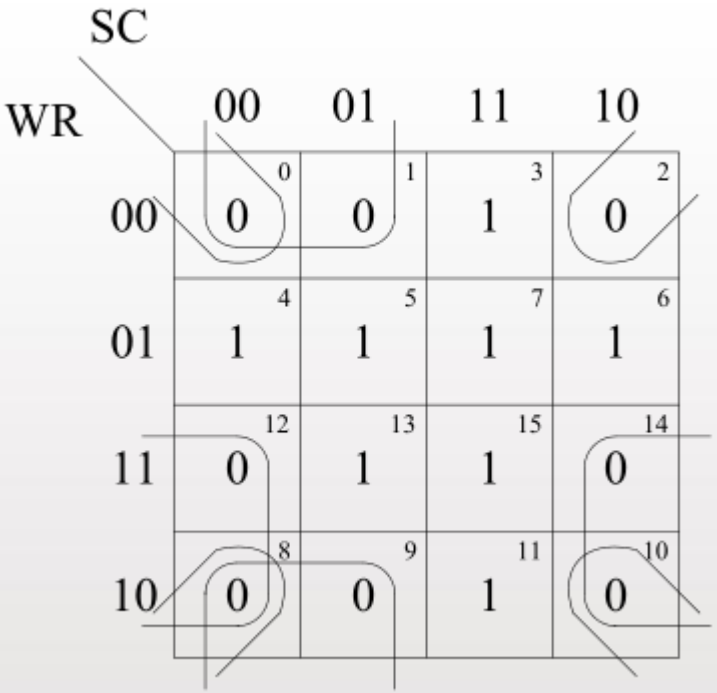
- To implement as NOR-NOR, U must be expressed in SOP form.

# Deriving the POS Equation

| W | R | S | C | U |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 0 |
| 0 | 0 | 1 | 0 | 0 |
| 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 |

| W | R | S | C | U |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 1 | 0 |
| 1 | 0 | 1 | 0 | 0 |
| 1 | 0 | 1 | 1 | 1 |
| 1 | 1 | 0 | 0 | 0 |
| 1 | 1 | 0 | 1 | 1 |
| 1 | 1 | 1 | 0 | 0 |
| 1 | 1 | 1 | 1 | 1 |

# Umbrella Controller POS Equation




$$U = (S + R)(\overline{W} + C)(R + C)$$

# Controller Circuit