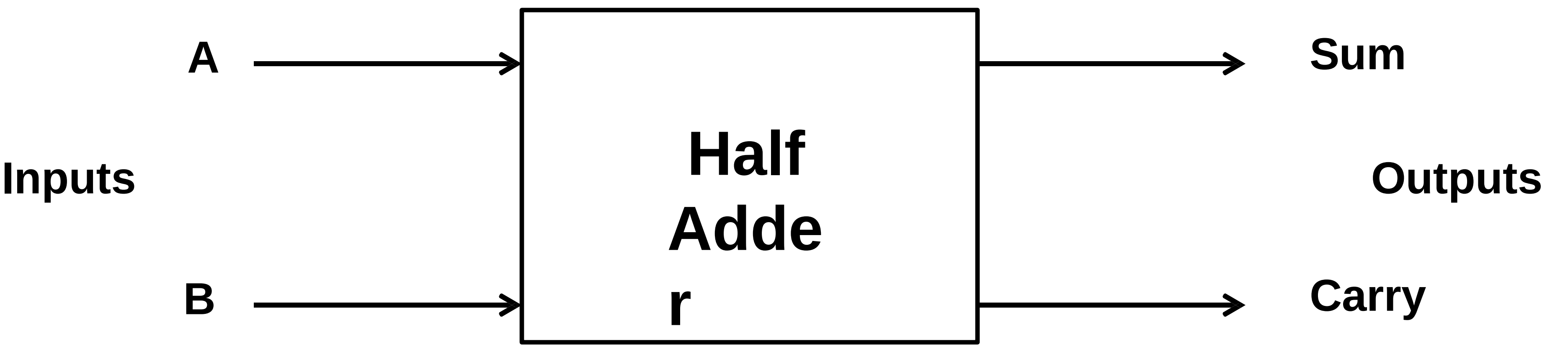
Half Adder

- ✓ Half adder is a combinational logic circuit with two inputs and two outputs.
- ✓ It is a basic building block for addition of two single bit numbers.



Half Adder

Truth Table for Half Adder

Input		Output	
A	**B**	**Sum (S)**	**Carry (C)**
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Half Adder

K-map for Sum Output:

B \ A	$\overline{A}$ 0	A 1
$\overline{B}$ 0	0	1
B 1	1	0

$$S = \overline{A}B + A\overline{B}$$

$$S = A \oplus B$$

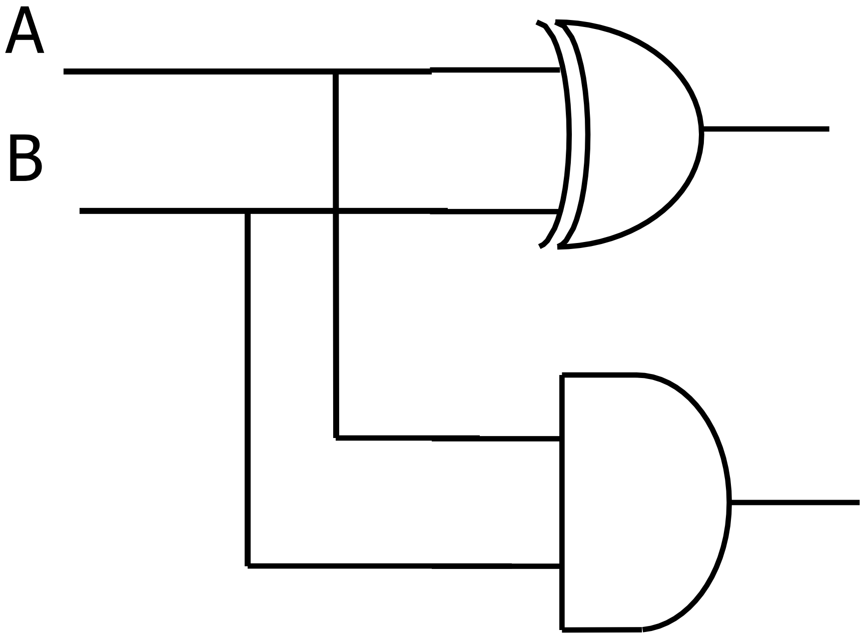
K-map for Carry Output:

B \ A	$\overline{A}$ 0	A 1
$\overline{B}$ 0	0	0
B 1	0	1

$$C = AB$$

Half Adder

Logic Diagram:

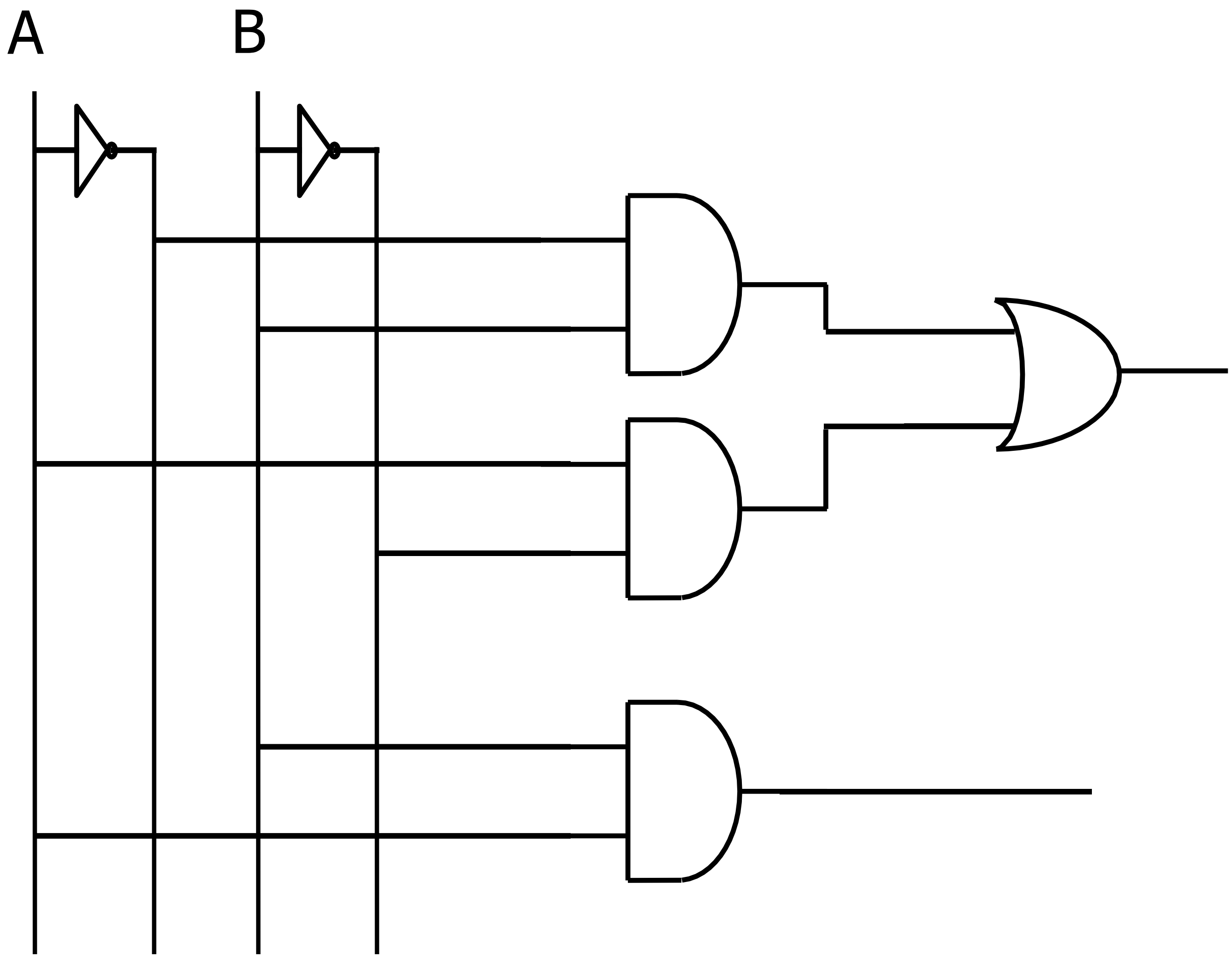


$$S = A \oplus B$$

$$C = AB$$

Half Adder

Logic Diagram using Basic Gates:



$S = A \oplus B$

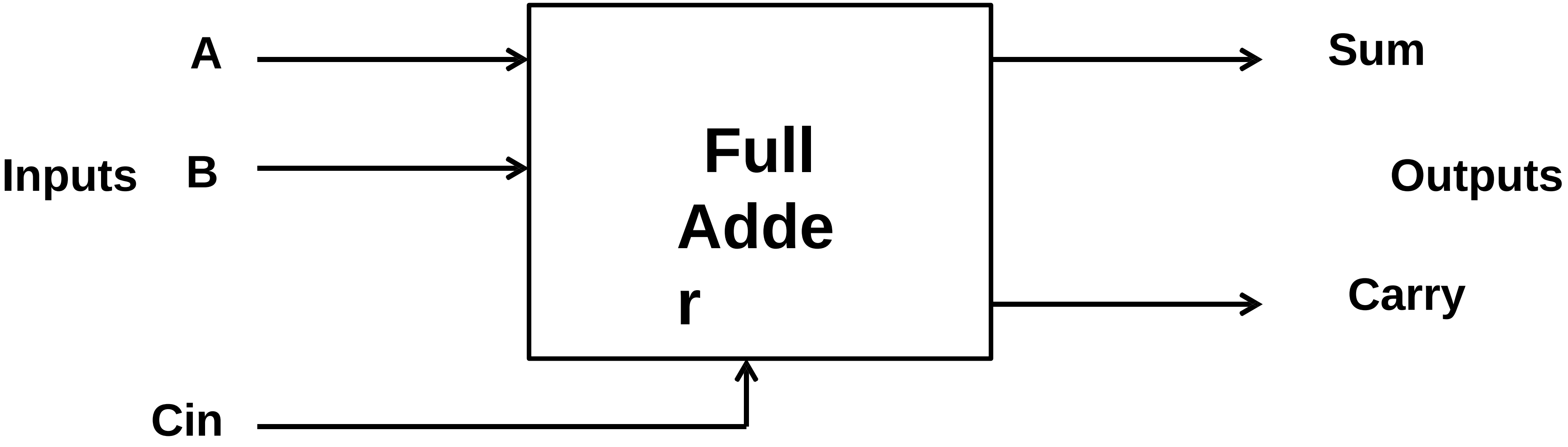
$C = AB$

Combinational Logic Circuits

- ✓ **Standard Boolean representation:** Sum of Product (SOP) & Product of Sum (POS), Maxterm and Minterm , Conversion between SOP and POS forms, realization using NAND/NOR gates.
- ✓ **K-map reduction technique for the Boolean expression:** Minimization of Boolean functions up to 4 variables (SOP & POS form)
- ✓ **Design of Airthmetic circuits and code converter using K-map:** Half and **Full Adder,** Half and Full Subtractor, Gray to Binary and Binary to Gray Code Converter (up to 4 bit).

Full Adder

✓ Full adder is a combinational logic circuit with three inputs and two outputs.



Full Adder

Truth Table

Inputs			Outputs	
A	**B**	**Cin**	**Sum (S)**	**Carry (C)**
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

Full Adder

K-map for Sum Output:

A \ BC	$\bar{B}\bar{C}$ 00	$\bar{B}C$ 01	BC 11	$B\bar{C}$ 10
$\bar{A}$ 0	0	1	0	1
A 1	1	0	1	0

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

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

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

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

$$Let \quad \bar{A}B + A\bar{B} = X$$

$$\therefore S = C(\bar{X}) + \bar{C}(X)$$

$$S = C \oplus X$$

$$Let \quad \mathrm{X} = A \oplus B$$

$$\because S = C \oplus A \oplus B$$

Full Adder

K-map for Carry Output:

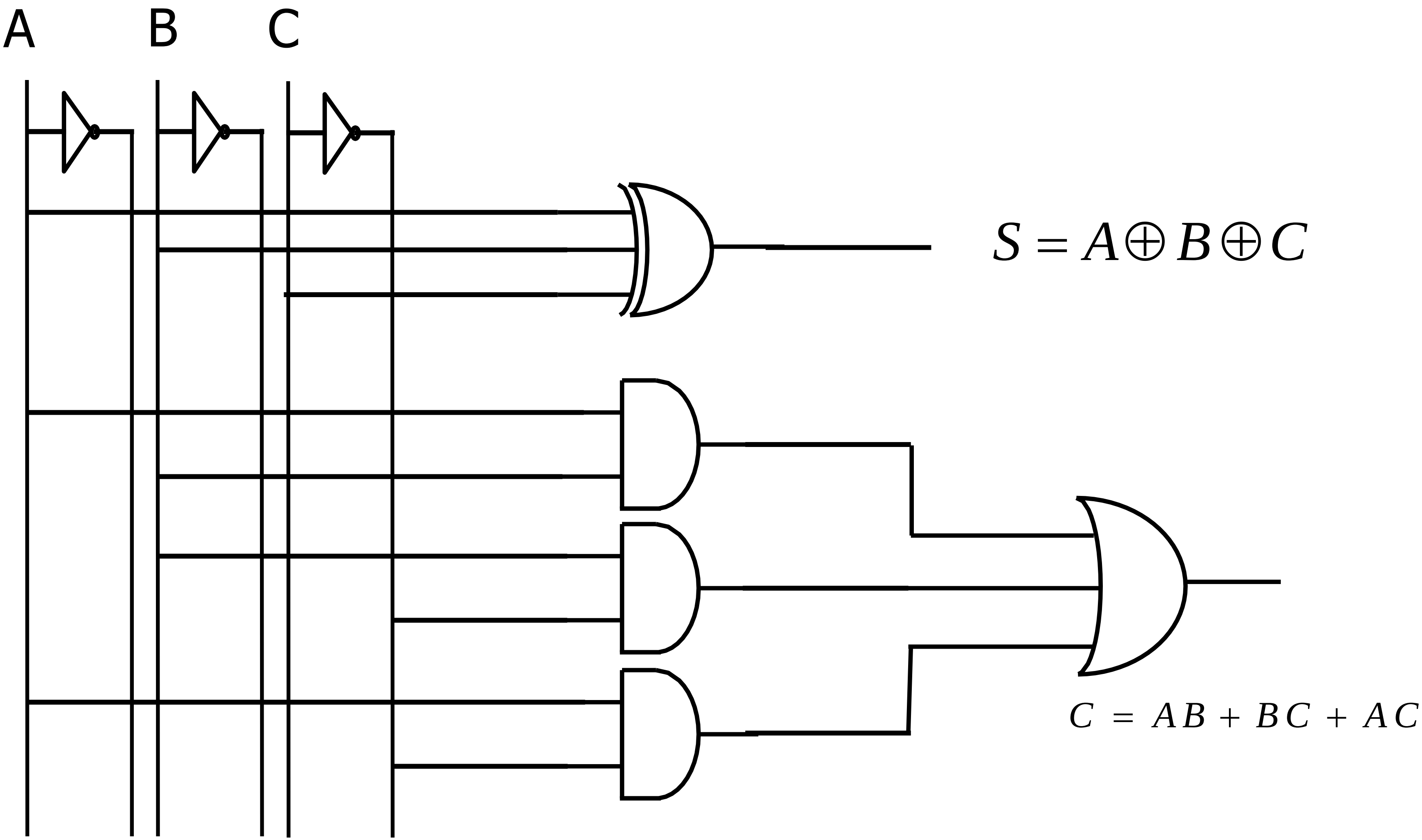
A \ BC	$\bar{B}\bar{C}$ 00	$\bar{B}C$ 01	BC 11	$B\bar{C}$ 10
$\bar{A}$ 0	0	0	1	0
A 1	0	1	1	1

BC AB AC

$$C = AB + BC + AC$$

Full Adder

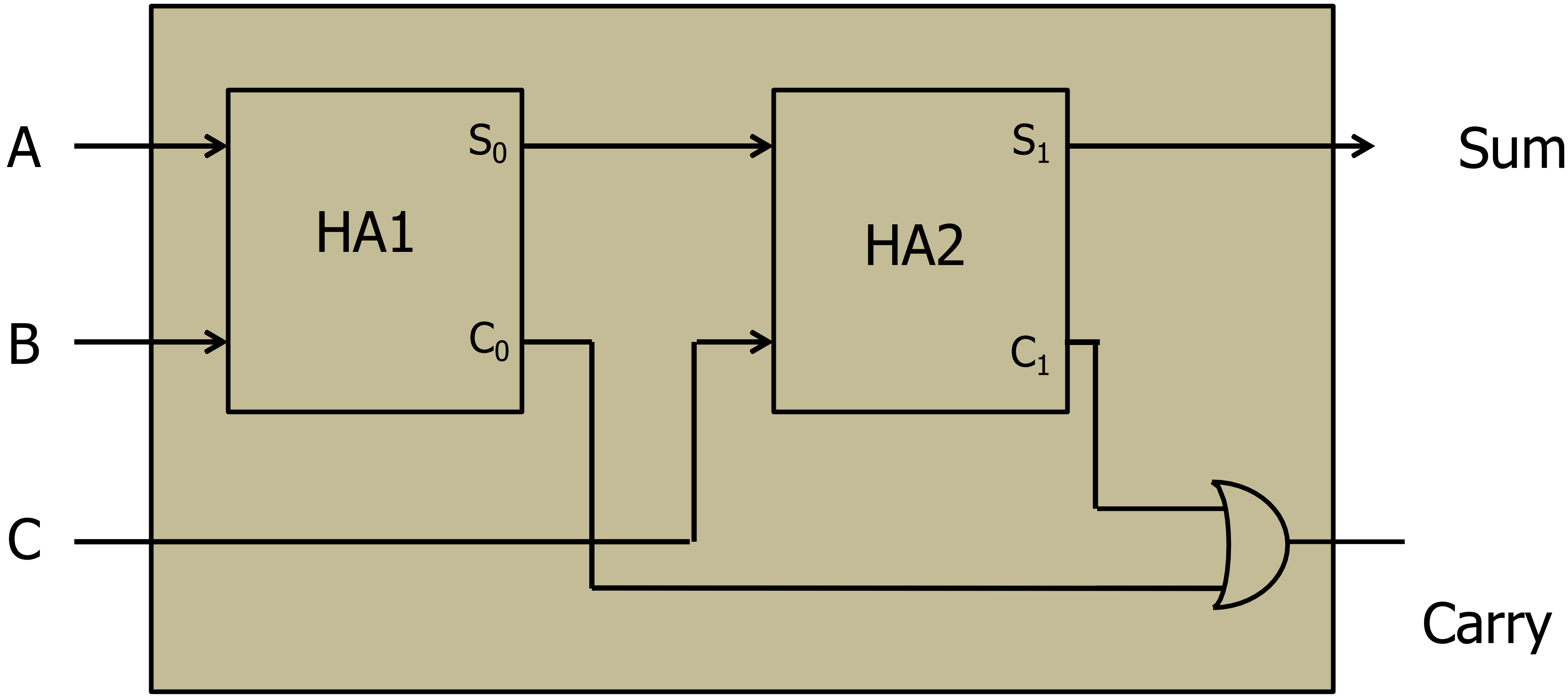
Logic Diagram:



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

$$C = AB + BC + AC$$

Full Adder using Half Adders

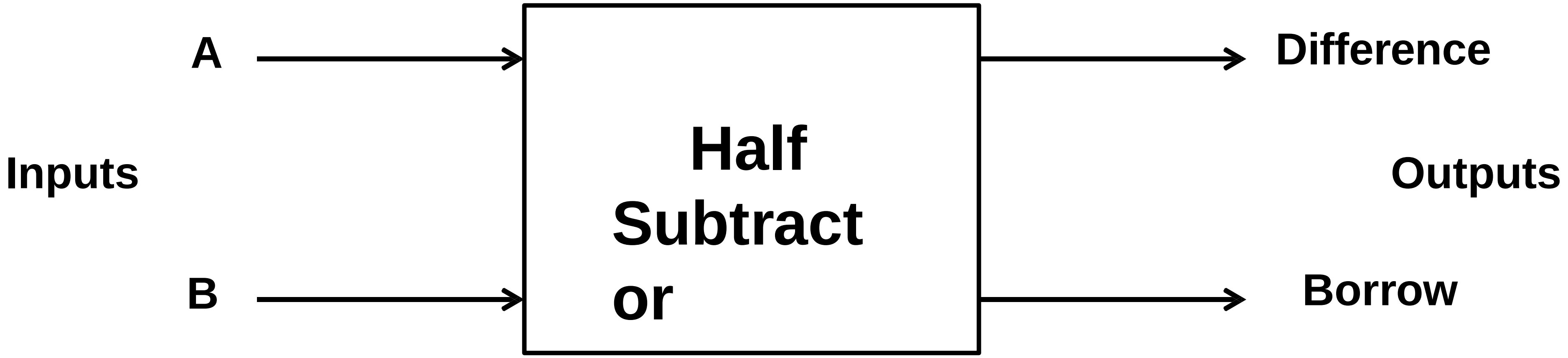


Combinational Logic Circuits

- ✓ **Standard Boolean representation:** Sum of Product (SOP) & Product of Sum (POS), Maxterm and Minterm , Conversion between SOP and POS forms, realization using NAND/NOR gates.
- ✓ **K-map reduction technique for the Boolean expression:** Minimization of Boolean functions up to 4 variables (SOP & POS form)
- ✓ **Design of Airthmetic circuits and code converter using K-map:** Half and Full Adder, **Half Subtractor** and Full Subtractor, Gray to Binary and Binary to Gray Code Converter (up to 4 bit).

Half Subtractor

- ✓ Half subtractor is a combinational logic circuit with two inputs and two outputs.
- ✓ It is a basic building block for subtraction of two single bit numbers.



Half Subtractor

Truth Table

Input		Output	
A	**B**	**Difference (D)**	**Borrow (B)**
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

Half Subtractor

K-map for Difference Output:

B \ A	$\overline{A}$ 0	A 1
$\overline{B}$ 0	0	1
B 1	1	0

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

$$D = A \oplus B$$

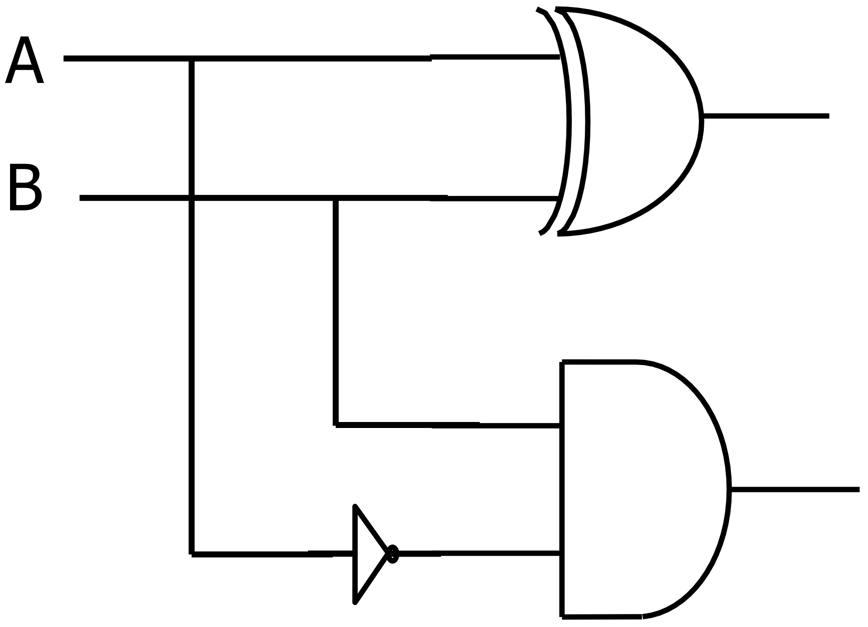
K-map for Borrow Output:

B \ A	$\overline{A}$ 0	A 1
$\overline{B}$ 0	0	1
B 1	0	0

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

Half Subtractor

Logic Diagram:

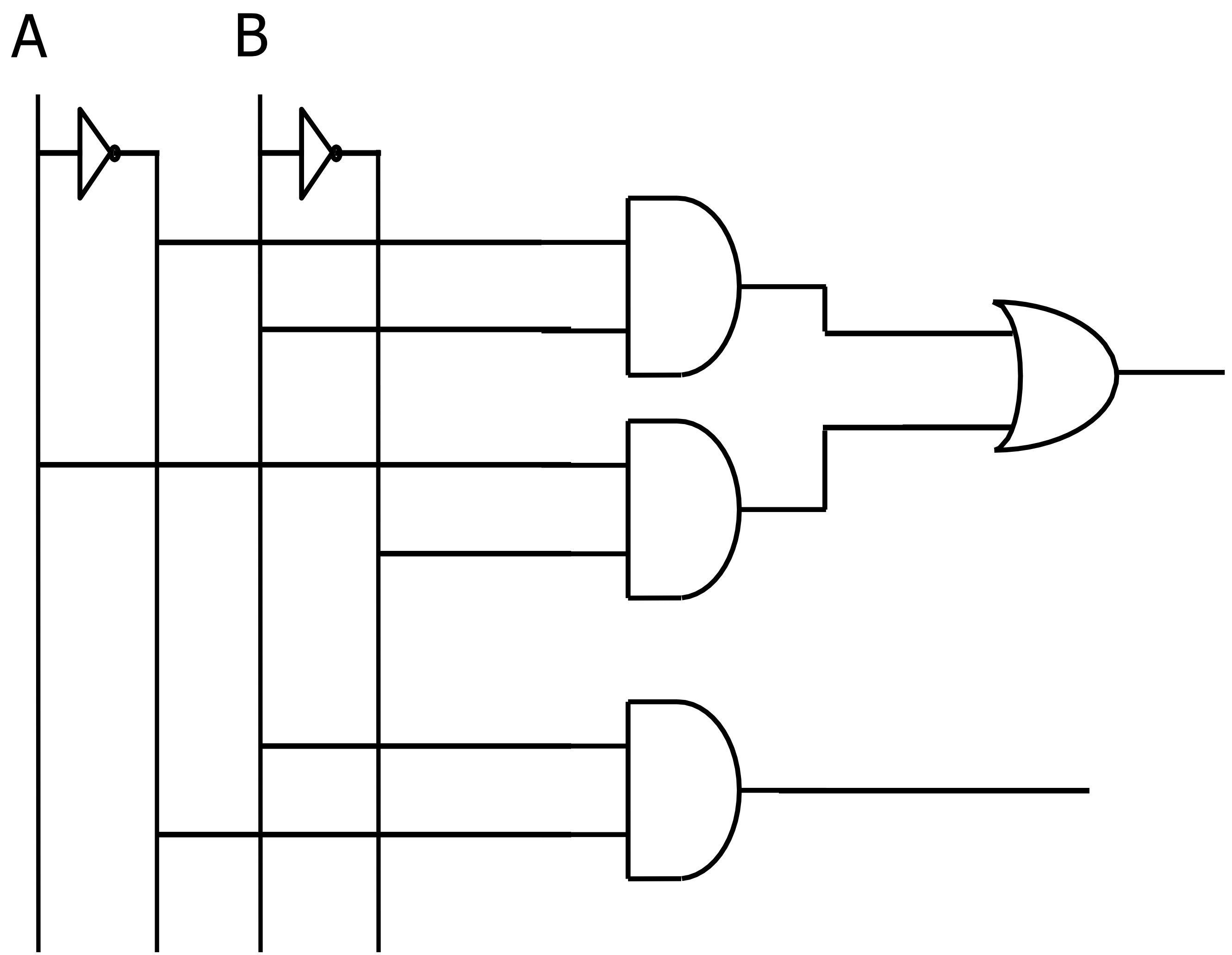


$$D = A \oplus B$$

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

Half Subtractor

Logic Diagram using Basic Gates:



$$D = A \oplus B$$

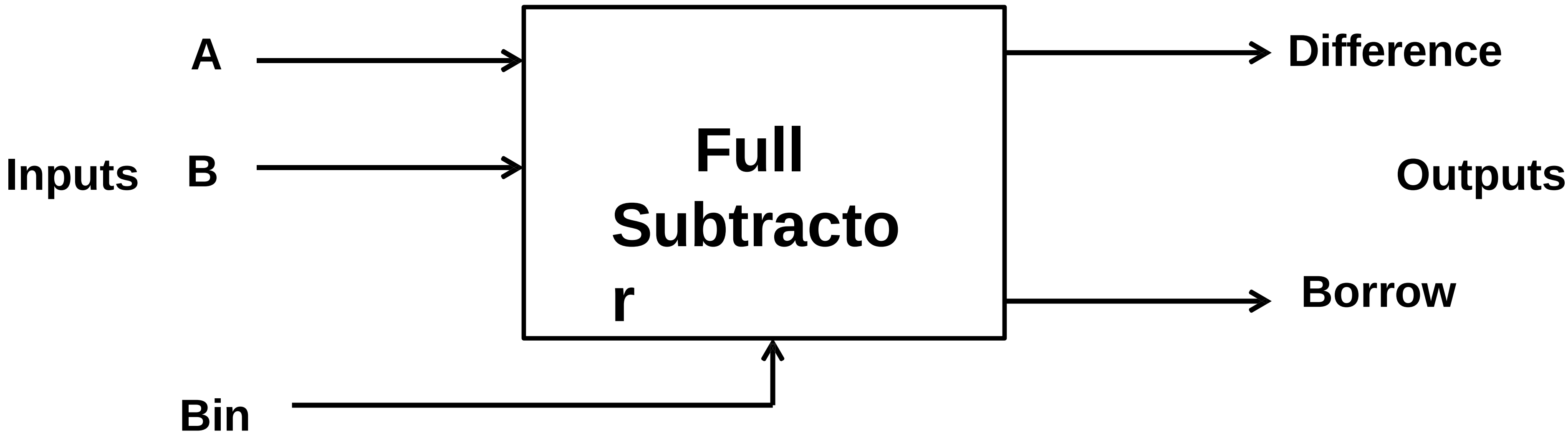
$$B = \overline{A}B$$

Combinational Logic Circuits

- ✓ **Standard Boolean representation:** Sum of Product (SOP) & Product of Sum (POS), Maxterm and Minterm , Conversion between SOP and POS forms, realization using NAND/NOR gates.
- ✓ **K-map reduction technique for the Boolean expression:** Minimization of Boolean functions up to 4 variables (SOP & POS form)
- ✓ **Design of Airthmetic circuits and code converter using K-map:** Half and Full Adder, Half and **Full Subtractor,** Gray to Binary and Binary to Gray Code Converter (up to 4 bit).

Full Subtractor

- ✓ Full subtractor is a combinational logic circuit with three inputs and two outputs.



Full Subtractor

Truth Table

Inputs			Outputs	
A	**B**	**Bin (C)**	**Difference (D)**	**Borrow (B0)**
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

Full Subtractor

K-map for Difference Output:

A \ BC	$\overline{B}\,\overline{C}$ 00	$\overline{B}C$ 01	BC 11	$B\overline{C}$ 10
$\overline{A}$ 0	0	1	0	1
A 1	1	0	1	0

$A\overline{B}\,\overline{C}$ $\quad$ $\overline{A}\,\overline{B}C$ $\quad$ ABC $\quad$ $\overline{A}B\overline{C}$

$$D = \overline{A}\,\overline{B}C + \overline{A}B\overline{C} + ABC + A\overline{B}\,\overline{C}$$

$$D = \overline{A}\,\overline{B}C + ABC + \overline{A}B\overline{C} + A\overline{B}\,\overline{C}$$

$$D = C(\overline{A}\,\overline{B} + AB) + \overline{C}(\overline{A}B + A\overline{B})$$

$$\text{Let} \qquad \overline{A}B + A\overline{B} = X$$

$$\therefore D = C(\overline{X}) + \overline{C}(X)$$

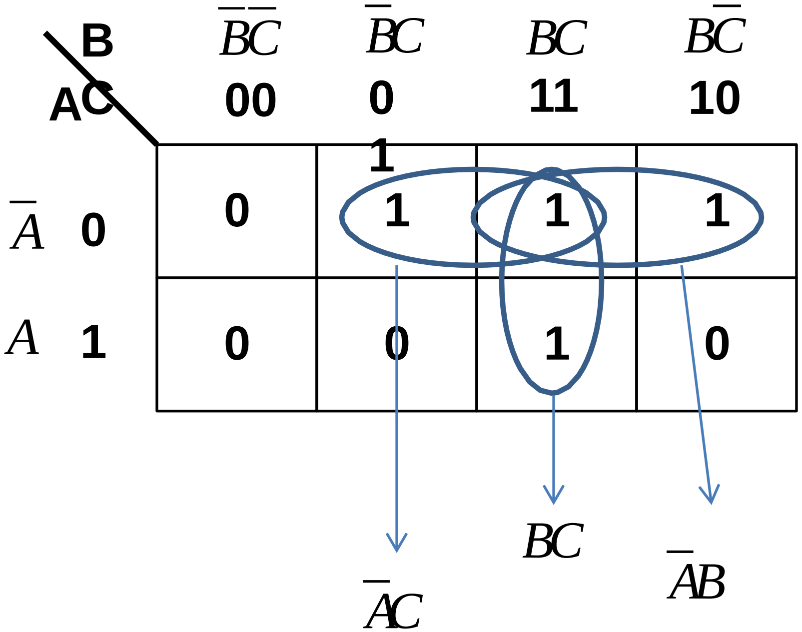
$$D = C \oplus X$$

$$\text{Let} \qquad \text{X} = A \oplus B$$

$$\because D = C \oplus A \oplus B$$

Full Subtractor

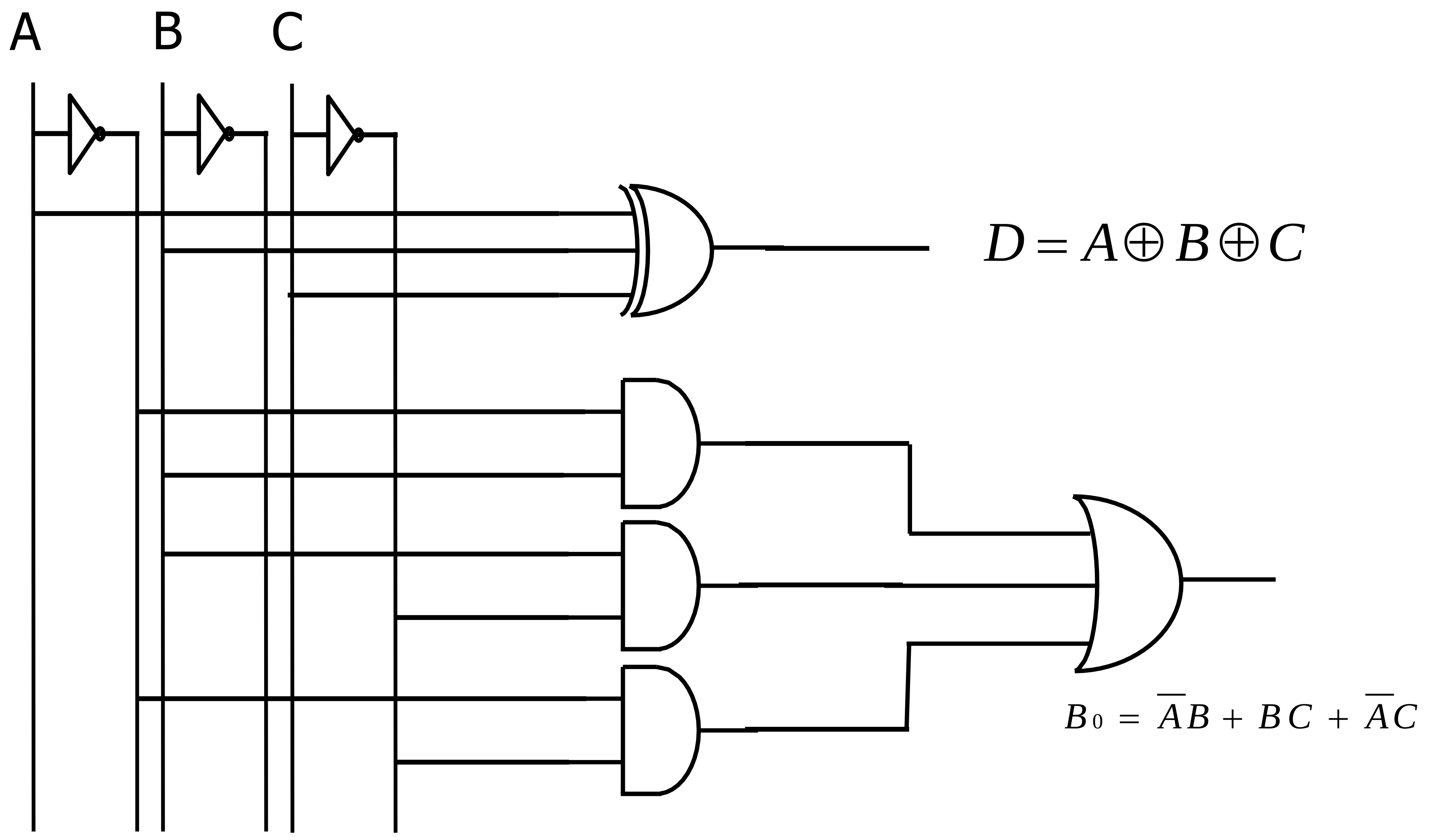
K-map for Borrow Output:



$$B_0 = \overline{A}B + BC + \overline{A}C$$

Full Subtractor

Logic Diagram:



Full Subtractor using Half Subtractor