SYNTHESIS OF LOGIC FUNCTIONS

COMBINATIONAL LOGIC CIRCUITS

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TOPIC OUTLINE

Synthesis of XOR/XNOR Gate

Synthesis of Logic Functions

SYNTHESIS OF XOR/XNOR GATE

SYNTHESIS

Cooking process analogy

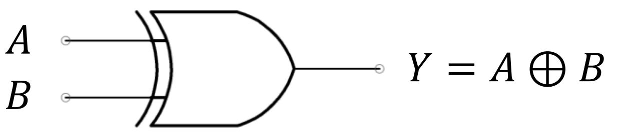
high-level
description

logic circuit

Synthesis is the process of transforming a high-level description of a desired functional behavior into a corresponding **hardware circuit** that implements that behavior.

EXCLUSIVE-OR GATE

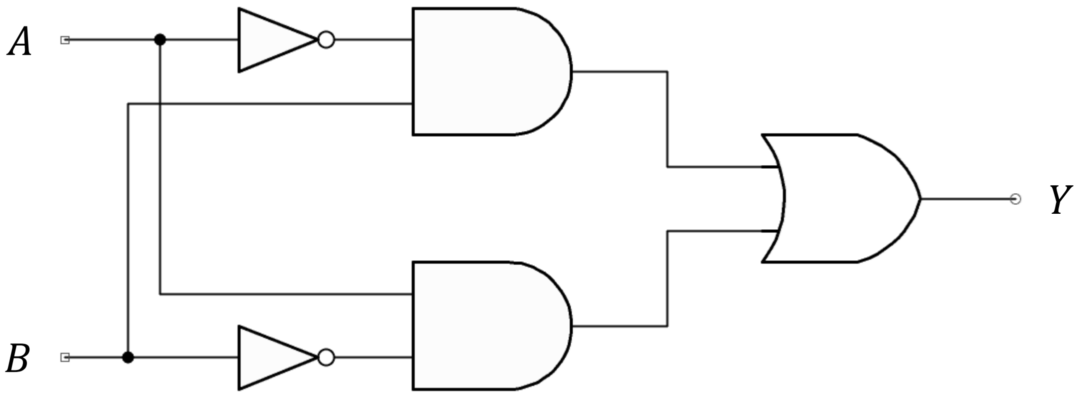
Logic Symbol



Truth Table

A	B	Y	Minterm
0	0	0	
0	1	1	$\bar{A}B$
1	0	1	$A\bar{B}$
1	1	0	

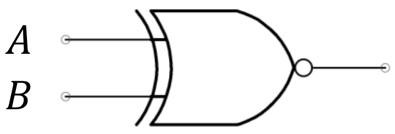
Equivalent Logic Circuit



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

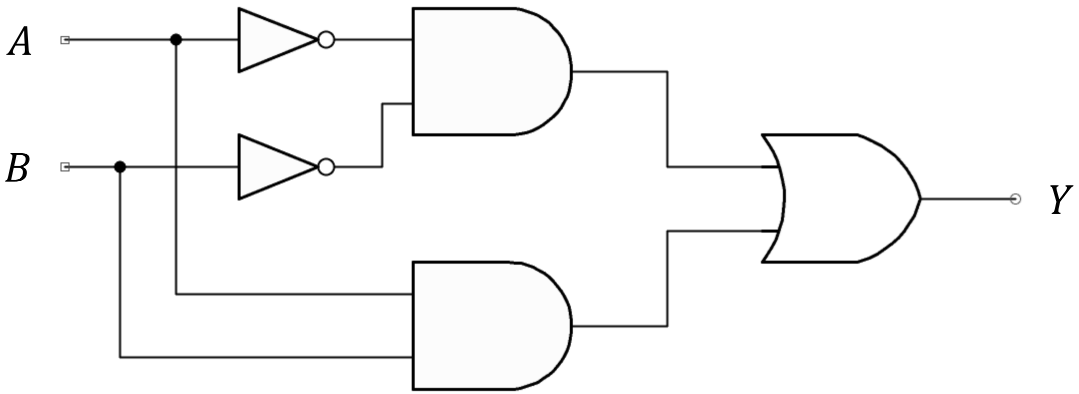
EXCLUSIVE-NOR GATE

Logic Symbol



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

Equivalent Logic Circuit



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

Truth Table

A	B	Y	Minterm
0	0	1	$\bar{A}\bar{B}$
0	1	0	
1	0	0	
1	1	1	AB

SYNTHESIS OF LOGIC FUNCTIONS

EXERCISE

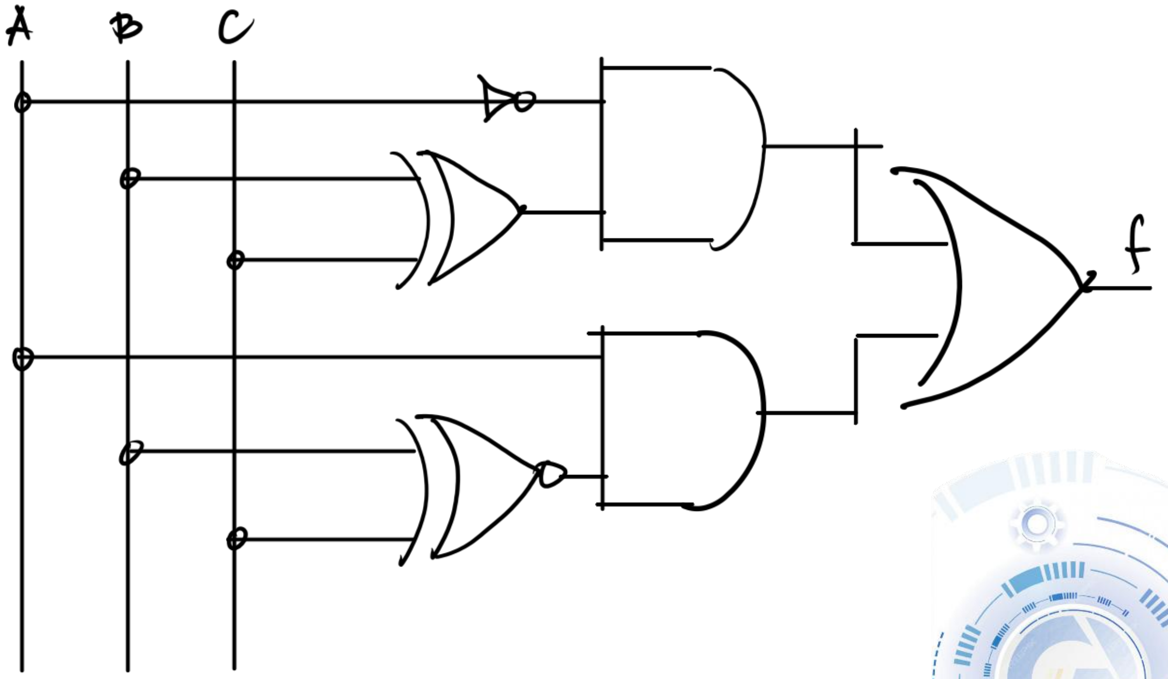
Synthesize the logic function describe by the truth table.

A	*B*	*C*	*f*	Minterm
0	0	0	0	
0	0	1	1	$\bar{A}\bar{B}C$
0	1	0	1	$\bar{A}B\bar{C}$
0	1	1	0	
1	0	0	1	$A\bar{B}\bar{C}$
1	0	1	0	
1	1	0	0	
1	1	1	1	ABC

Solution

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

$$f = \bar{A}(\underbrace{\bar{B}C + B\bar{C}}_{XOR}) + A(\underbrace{\bar{B}\bar{C} + BC}_{XNOR})$$



EXERCISE

A section of a bubble gumball factory uses a conveyor system equipped with three sensors—s_1,s_2, and s_3 to inspect each gumball.

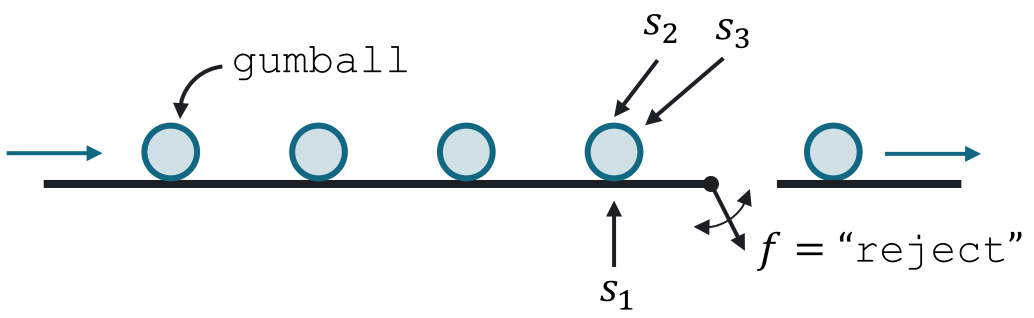
- $s_1 = 1$ if the gumball is too light.
- $s_2 = 1$ if the gumball is too small in diameter.
- $s_3 = 1$ if the gumball is too large in diameter

The conveyor moves gumballs over a trap door that rejects defective ones. A gumball should be rejected if:

- It is too large ($s_3 = 1$), or
- It is both too light and too small ($s_1 = 1$ & $s_2 = 1$).

Synthesize a logic circuit that activates the trap door based on the sensor outputs.

Conveyor and Sensors

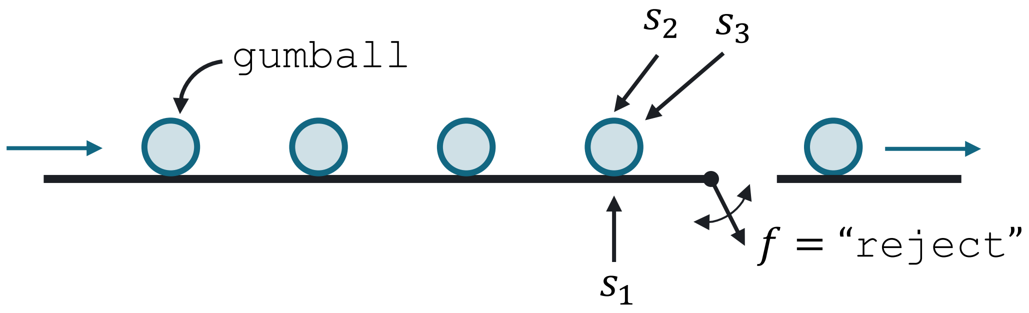


EXERCISE

Solution

S_1	S_2	S_3	f	Minterm
0	0	0	0	
0	0	1	1	$\bar{S}_1 \bar{S}_2 S_3$
0	1	0	0	
0	1	1	1	$\bar{S}_1 S_2 S_3$
1	0	0	0	
1	0	1	1	$S_1 \bar{S}_2 S_3$
1	1	0	1	$S_1 S_2 \bar{S}_3$
1	1	1	1	$S_1 S_2 S_3$

Conveyor and Sensors



$$f = \bar{S}_1 \bar{S}_2 S_3 + \bar{S}_1 S_2 S_3 + S_1 \bar{S}_2 S_3 + S_1 S_2 \bar{S}_3 + S_1 S_2 S_3 + S_1 S_2 S_3$$

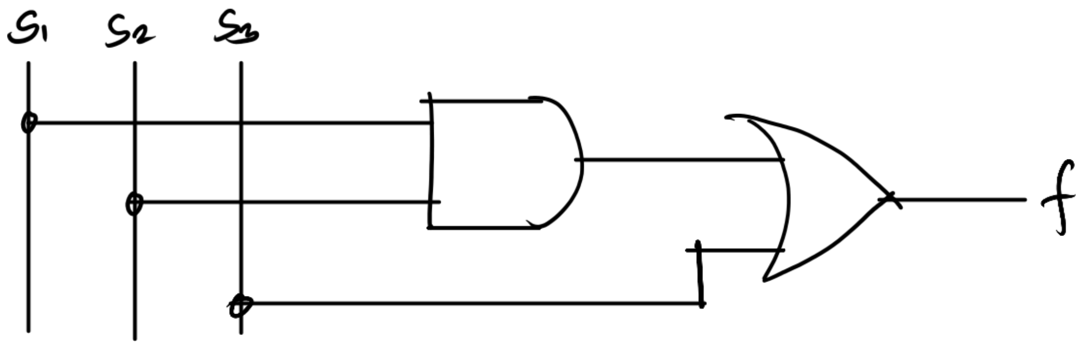
$$f = \bar{S}_1 S_3 (\cancelto{1}{\bar{S}_2 + S_2}) + S_1 S_3 (\cancelto{1}{\bar{S}_2 + S_2}) + S_1 S_2 (\cancelto{1}{\bar{S}_3 + S_3})$$

$$f = \bar{S}_1 S_3 + S_1 S_3 + S_1 S_2$$

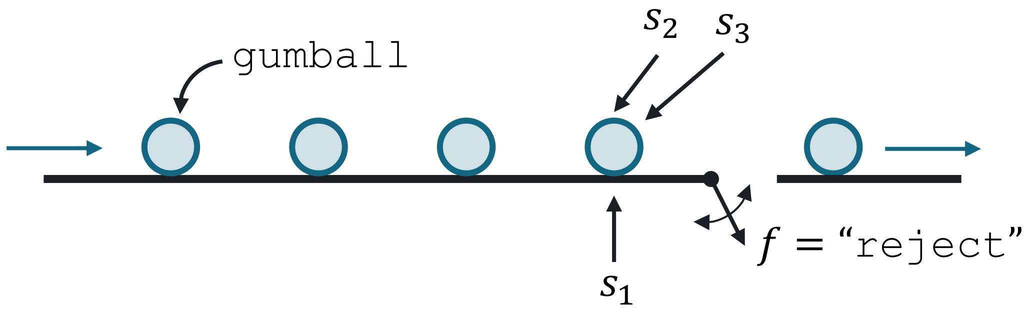
$$f = S_3 + S_1 S_2$$

EXERCISE

Solution



Conveyor and Sensors



$$f = \bar{s}_1 \bar{s}_2 s_3 + \bar{s}_1 s_2 s_3 + s_1 \bar{s}_2 s_3 + s_1 s_2 \bar{s}_3 + s_1 s_2 s_3 + s_1 s_2 s_3$$

$$f = \bar{s}_1 s_3 \left(\cancelto{1}{\bar{s}_2 + s_2}\right) + s_1 s_3 \left(\cancelto{1}{\bar{s}_2 + s_2}\right) + s_1 s_2 \left(\cancelto{1}{\bar{s}_3 + s_3}\right)$$

$$f = \bar{s}_1 s_3 + s_1 s_3 + s_1 s_2$$

$$f = s_3 + s_1 s_2$$

EXERCISE

Synthesize a logic circuit that controls a single light in a large room with three entry points, each equipped with a switch. The behavior of this three-way light control are as follows:

$A=0,\ B=0,\ C=0$

1. The light is OFF when all three switches are open.
2. Closing any one of the switches turns the light ON.
3. If two switches are closed simultaneously, the light turns OFF.

$A=1,\ B=1,\ C=1$

4. If all three switches are closed, the light turns ON again.

Input

0 – open

1 – closed

Output

0 – OFF

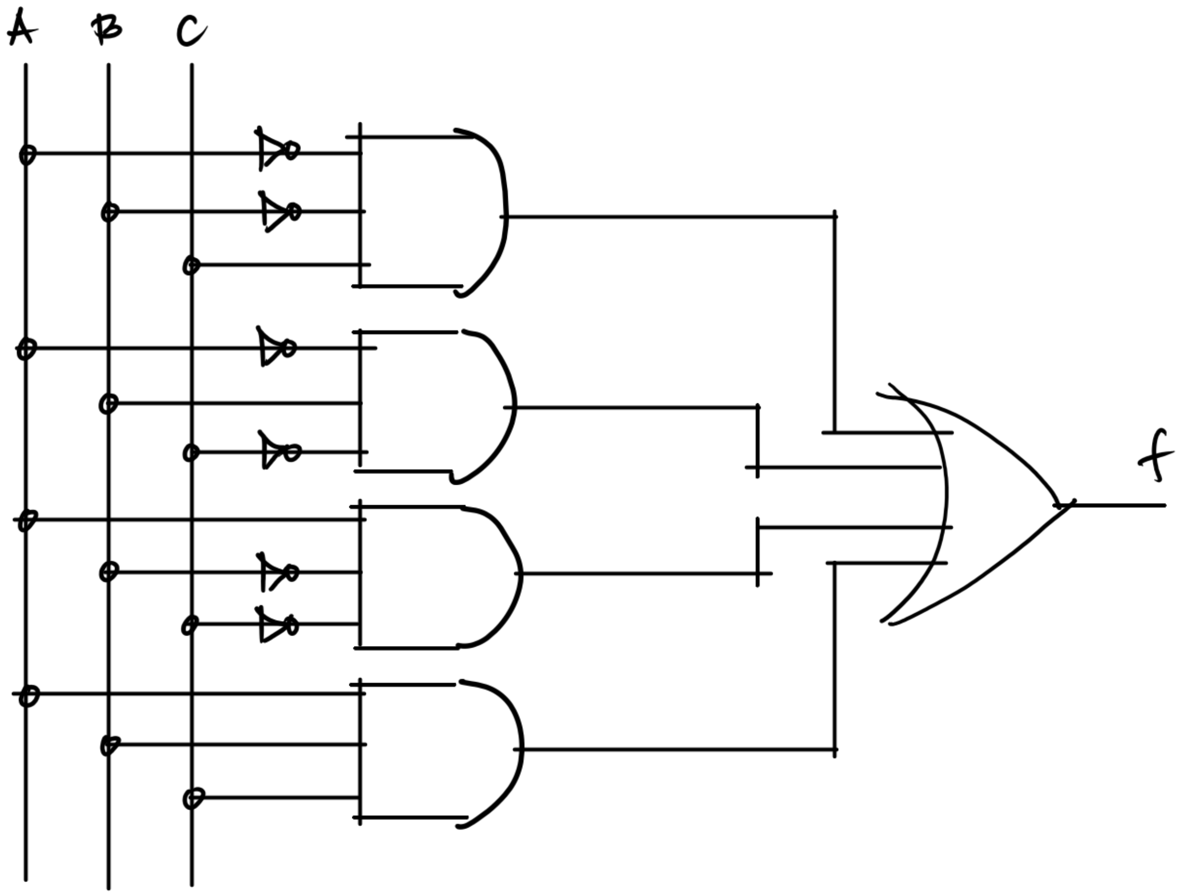
1 – ON

Solution

A	B	C	f	Minterm
0	0	0	0	
0	0	1	1	$\bar{A}\bar{B}C$
0	1	0	1	$\bar{A}B\bar{C}$
0	1	1	0	
1	0	0	1	$A\bar{B}\bar{C}$
1	0	1	0	
1	1	0	0	
1	1	1	1	ABC

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

EXERCISE



Solution

A	B	C	f	Minterm
0	0	0	0	
0	0	1	1	$\bar{A}\bar{B}C$
0	1	0	1	$\bar{A}B\bar{C}$
0	1	1	0	
1	0	0	1	$A\bar{B}\bar{C}$
1	0	1	0	
1	1	0	0	
1	1	1	1	ABC

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

LABORATORY