MULTIPLEXER

COMBINATIONAL LOGIC CIRCUITS

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TOPIC OUTLINE

Synthesis of Logic Functions

Shannon’s Expansion Theorem

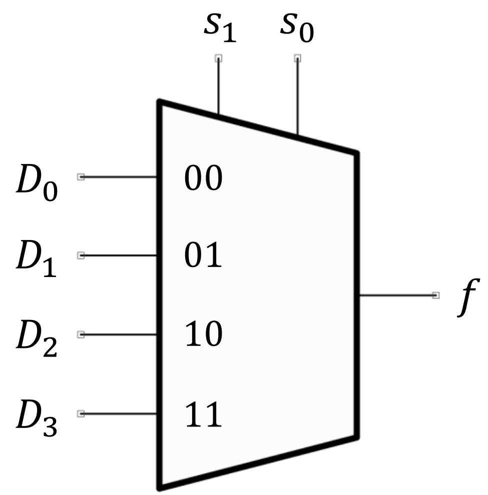
SYNTHESIS OF LOGIC FUNCTIONS

MULTIPLEXER

A **multiplexer** circuit has several data inputs, one or more select inputs, and **one output**. It passes the signal value on one of the data inputs to the output.

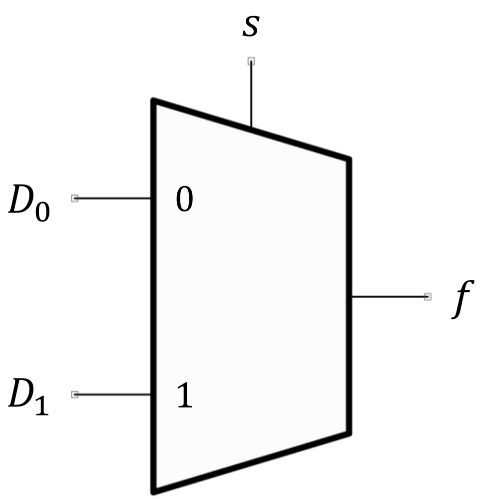
A multiplexer that has n data inputs $(D_0, D_1, \ldots D_{n-1})$, requires $[\log_2 n]$ select inputs.

4-to-1 Multiplexer



2-TO-1 MUX

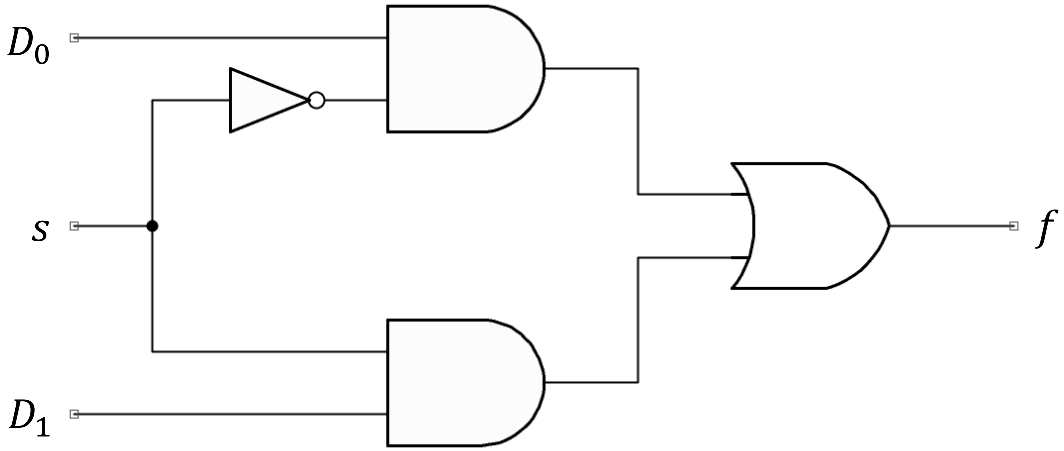
Graphical Symbol



Truth Table

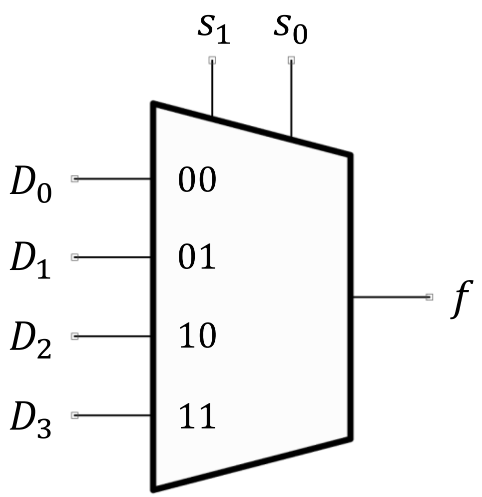
s	f
0	D_0
1	D_1

Sum-of-Products Implementation



4-TO-1 MUX

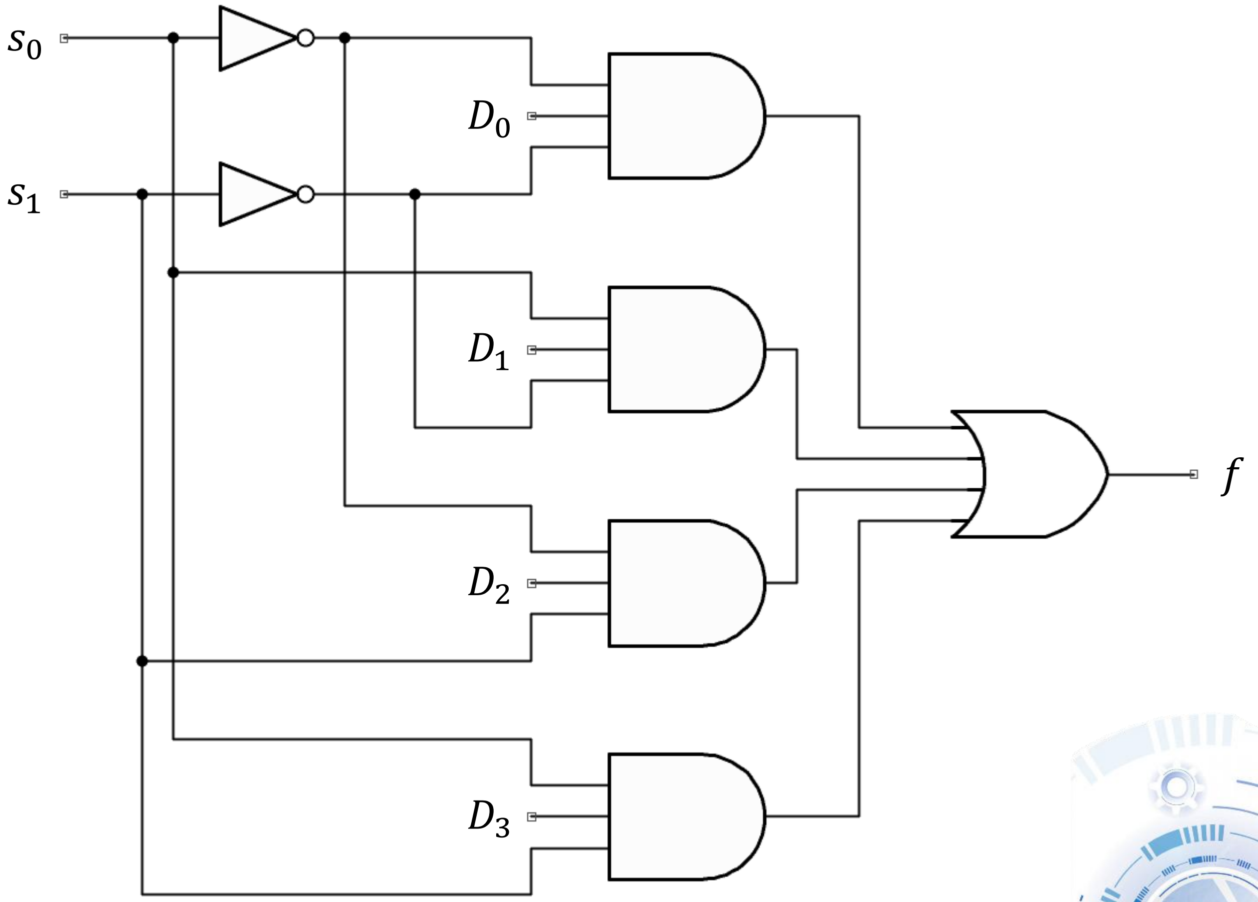
Graphical Symbol



Truth Table

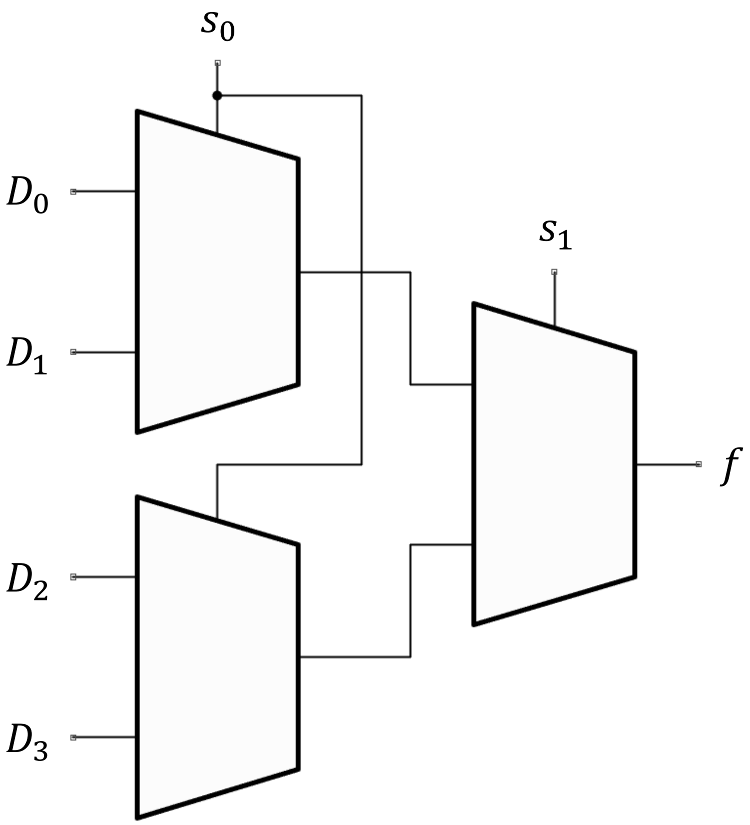
s_1	s_0	f
0	0	D_0
0	1	D_1
1	0	D_2
1	1	D_3

Sum-of-Products Implementation

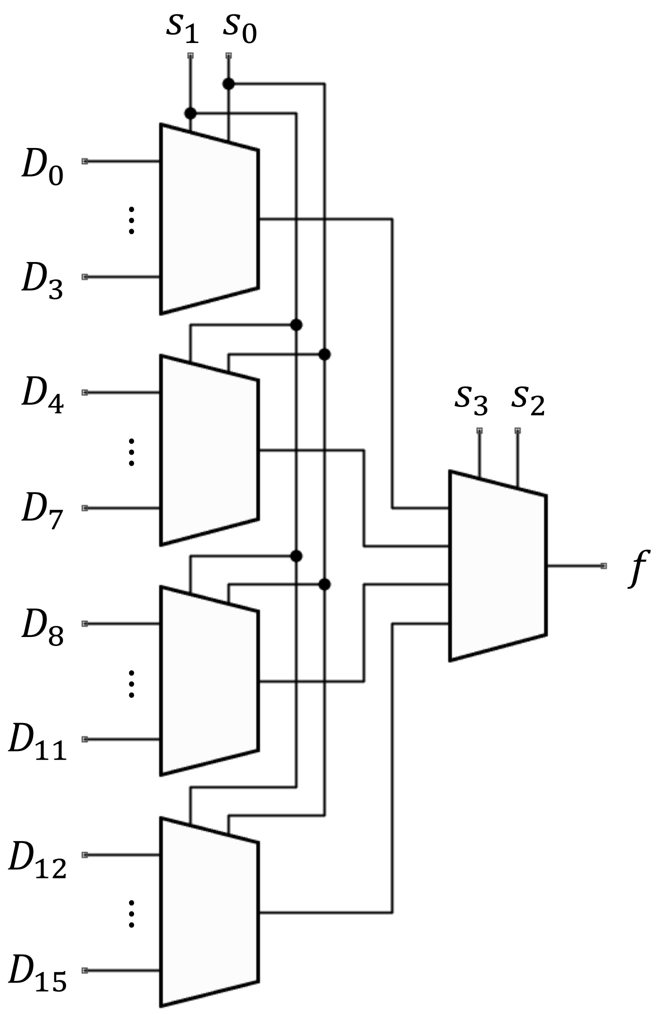


USING 2-TO-1 MUX

Using 2-to-1 MUX to build a 4-to-1 MUX



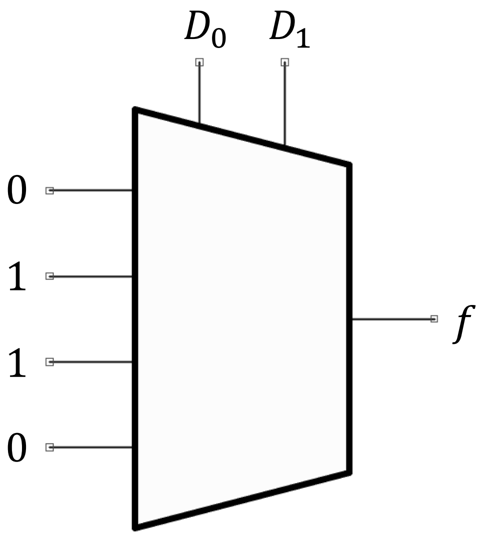
Using 2-to-1 MUX to build a 16-to-1 MUX



XOR LOGIC GATE

Implementation using 4-to-1 MUX

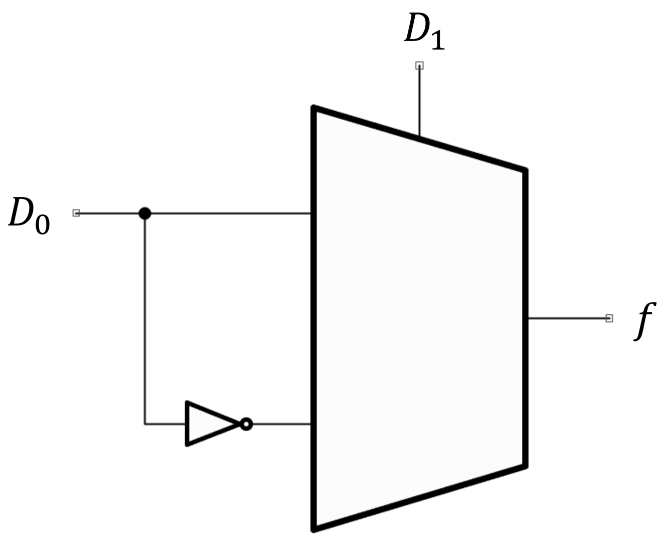
D_1	D_0	f	Minterm
0	0	0	
0	1	1	$\bar{D}_1 D_0$
1	0	1	$D_1 \bar{D}_0$
1	1	0	



Implementation using 2-to-1 MUX

D_1	f
0	D_0
1	$\bar{D}_0$

Modified Truth Table



EXERCISE

Implement the logic function described by the truth table using a 4-to-1 multiplexer configuration.

Solution

D_2	D_1	D_0	f
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

EXERCISE

Implement the logic function described by the truth table using a 2-to-1 multiplexer configuration.

Solution

EXERCISE

Implement the three-input XOR described by the truth table using a 4-to-1 multiplexer configuration.

D_2	D_1	D_0	f
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

Solution

EXERCISE

Implement the three-input XOR described by the truth table using a 2-to-1 multiplexer configuration.

Solution

SHANNON'S EXPANSION THEOREM

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Shannon's expansion theorem states that any Boolean function $f(x_0, x_1 \dots, x_{n-1})$ can be written in the form:

$$\boldsymbol{f(x_0, x_1, \dots x_{n-1}) = \bar{x}_1 f_{\bar{x}_1} + x_1 f_{x_1}}$$

where

$f_{\bar{x}_1}$ = the cofactor of f with respect to $\bar{x}_1$

$= (x_0, \mathbf{0}, \dots x_{n-1})$

f_{x_1} = the cofactor of f with respect to x_1

$= (x_0, \mathbf{1}, \dots x_{n-1})$

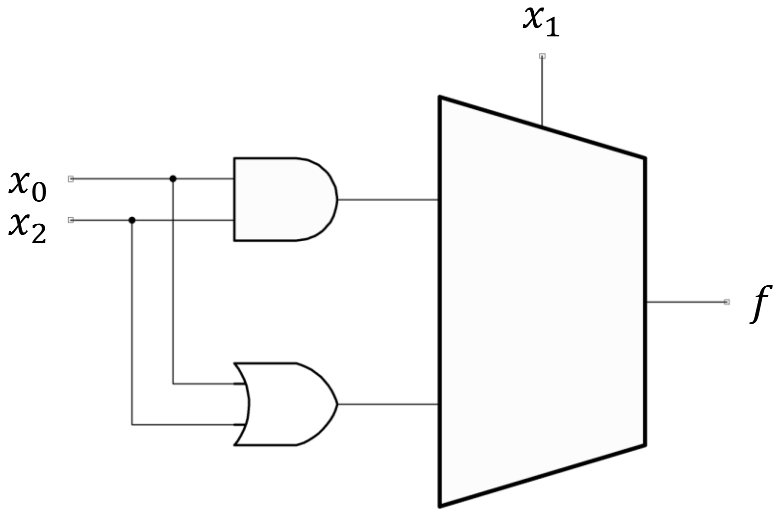
Expanding the given function with respect to x_1

$$f(x_0, x_1, x_2) = x_0 x_1 + x_0 x_2 + x_1 x_2$$

$$f(x_0, x_1, x_2) = \bar{x}_1(x_0 \cdot 0 + x_0 x_2 + 0 \cdot x_2)$$
$$+ x_1(x_0 \cdot 1 + x_0 x_2 + 1 \cdot x_2)$$

$$f(x_0, x_1, x_2) = \bar{x}_1(x_0 x_2) + x_1(x_0 + x_0 x_2 + x_2)$$

$$f(x_0, x_1, x_2) = \bar{x}_1(x_0 x_2) + x_1(x_0 + x_2)$$



EXERCISE

Implement the logic function described by the truth table using Shannon's decomposition method.

Solution

D_2	D_1	D_0	f
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

EXERCISE

Implement the three-input XOR described by the truth table using a Shannon's decomposition method.

Solution

D_2	D_1	D_0	f
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

EXERCISE

Design a full-adder circuit using Shannon's decomposition method and simulate it in Multisim using the 74151 multiplexer.

A	B	C_{in}	C_{out}	Σ
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

Solution

LABORATORY