MULTIPLEXER / MUX / DATA SELECTOR

Multiplexers

- A multiplexer is a combinational circuit that selects one of many input lines (2^n) and directs it to its single output line.
- There are n selection lines whose bit combinations determine which input is selected.
- A multiplexer is also called a data selector, since it selects one of many inputs and steers the binary information to the output line.
- The size of a multiplexer is specified by the number 2^n of its input lines and the single output line. It is then implied that it also contains n selection lines.
- Example: 2X1 MUX, 4X1 MUX, 8X1 MUX, 16X1 MUX etc.

Multiplexers

- 4-to-1 MUX

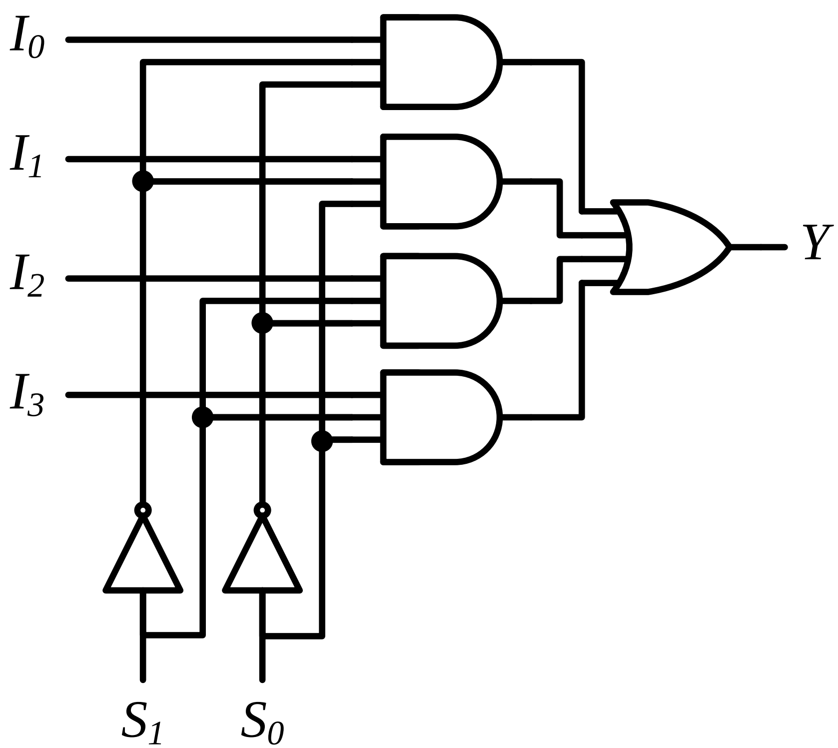


Fig: Logic diagram of a 4X1 MUX

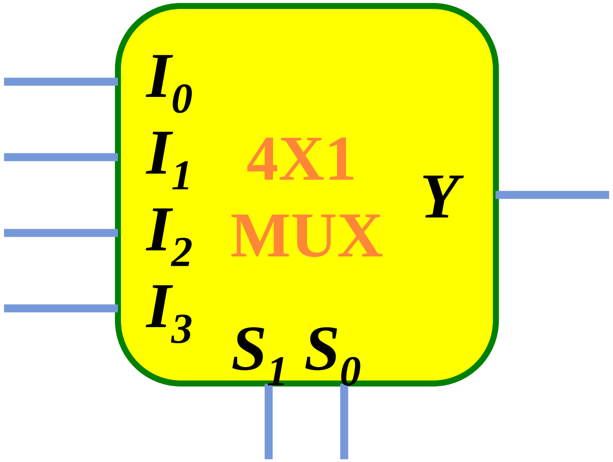


Fig: Block diagram of a 4X1 MUX

Function Table of a 4X1 MUX:

S_1 S_0	Y
0 0	I_0
0 1	I_1
1 0	I_2
1 1	I_3

Output Equation:

$$Y = S_1'S_0'I_0 + S_1'S_0I_1 + S_1S_0'I_2 + S_1S_0I_3$$

Uses of MUX

- It is used for connecting two or more sources to a single destination among computer units.

- It is useful for constructing a common bus system etc.

Function Implementation using MUX

- (n+1) variable function can be implemented with $2^n \times 1$ MUX
- Simplify the function in sum of minterms form
- Among (n+1) variables, n variables are used as selector and one variable is connected with input lines

$$f(\underbrace{A}_{\text{Input}}, \underbrace{B, C, D, E, \ldots..}_{\text{Selectors}})$$

Procedure 1

Implementation Using Multiplexers: Procedure 1

$F(A, B, C) = \sum(1, 3, 5, 6)$

Steps:

1. Choose the selector variables.
   Lets choose,
   - B, C as selector S_1 and S_0
   - A as input line
2. In the first row, list the name of the input lines of the multiplexers horizontally
3. In the second row, list the minterms where A is complemented
4. In the third row, list the minterms where A is uncomplemented

Implementation Using Multiplexers: Procedure 1

$F(A, B, C) = \sum(1, 3, 5, 6)$

Steps:

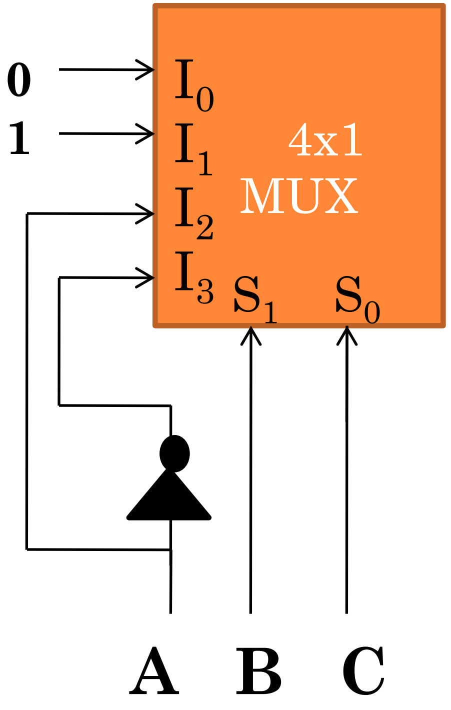
5. Circle the minterms for which the function outputs 1
6. Fourth row presents the multiplexer inputs
   - If the two minterms in a column are not circled, apply 0 to the corresponding multiplexer input
   - If the two minterms in a column are circled, apply 1 to the corresponding multiplexer input
   - If the bottom minterm is circled and the top is not circled, apply A to the corresponding multiplexer input
   - If the top minterm is circled and the bottom is not circled, apply A' to the corresponding multiplexer input

Implementation Using Multiplexers: Procedure 1

- $F(A, B, C) = \sum(1, 3, 5, 6)$

Implementation Table:

MUX input line	I_0	I_1	I_2	I_3
A'	0	1	2	3
A	4	5	6	7
Input values	0	1	A	A'



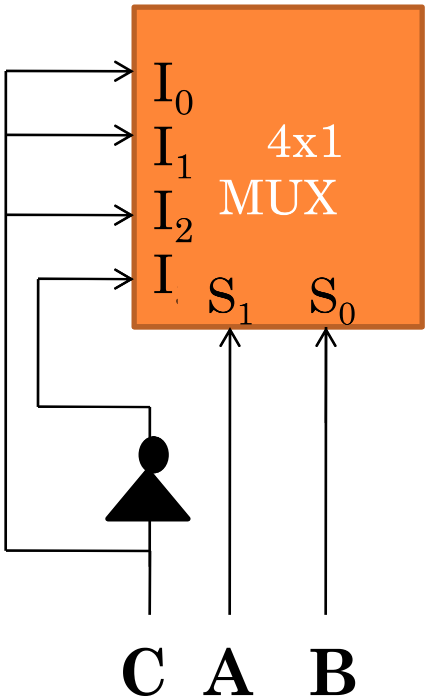
Implementation Using Multiplexers: Procedure 1

- $F(A, B, C) = \sum(1, 3, 5, 6)$

What if A, B are the selectors and C goes to input line?

Implementation Table:

MUX input line	I_0	I_1	I_2	I_3
C'	0	2	4	6
C	1	3	5	7
Input values	C	C	C	C'



Procedure 2

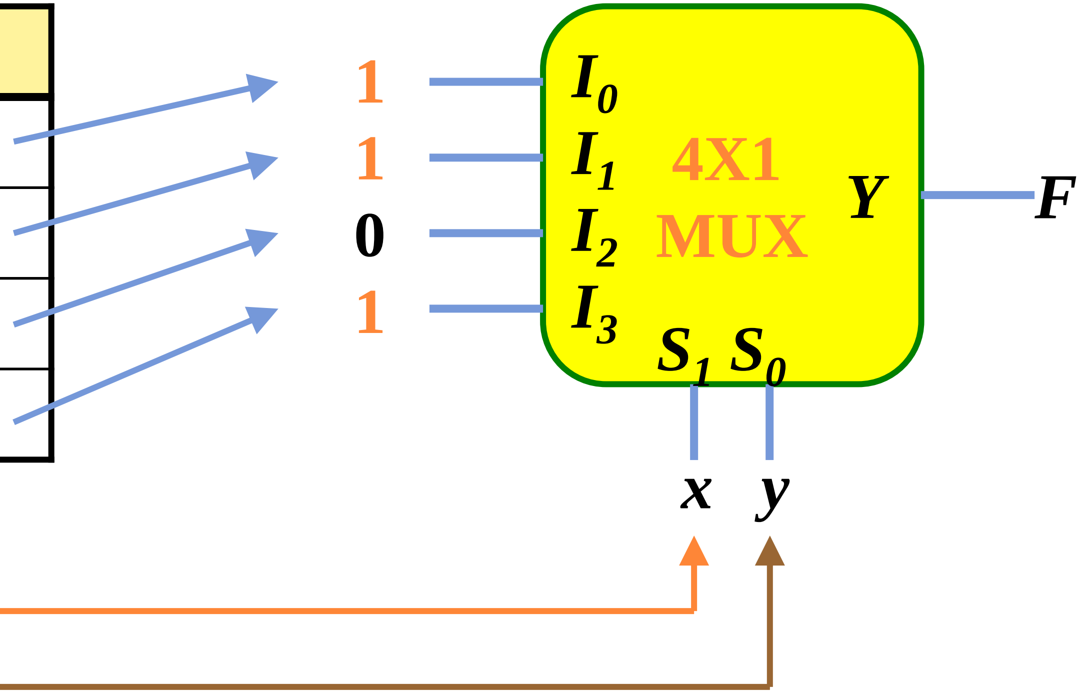
Implementation Using Multiplexers: Procedure 2

- Steps:
  1. Complete the truth table from the SOP.
  2. The first *n – 1 variables in the table are applied to the* selection inputs of the multiplexer.
  3. For each combination of the selection variables, we evaluate the output as a function of the last variable.
  4. Apply these values to the data input in proper order.

Implementation Using Multiplexers: Procedure 2

- Example $F(x, y) = \sum(0, 1, 3)$

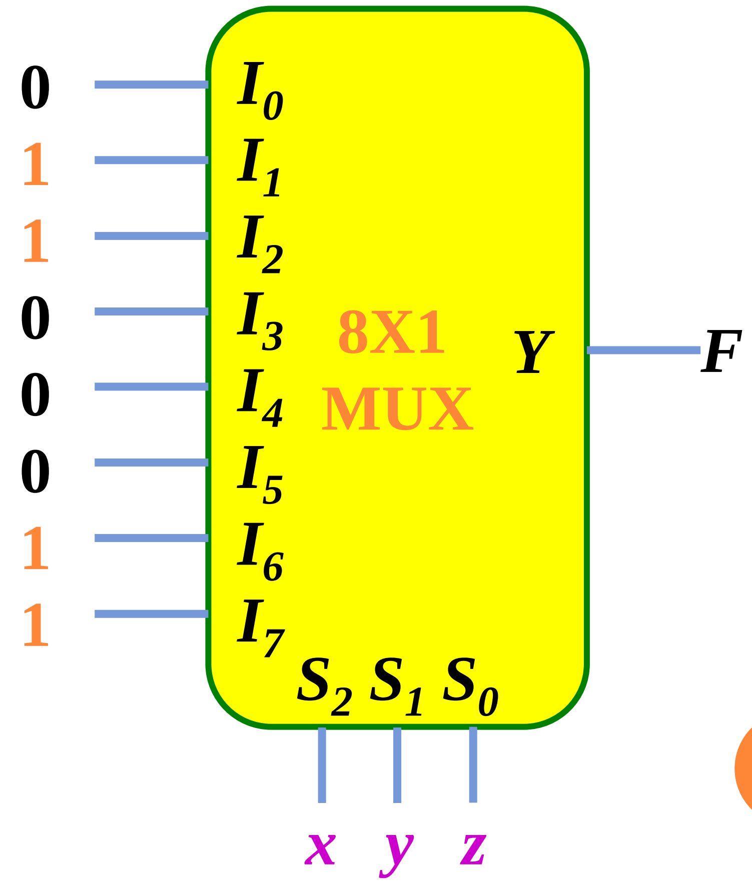
x	y	F
0	0	1
0	1	1
1	0	0
1	1	1



Implementation Using Multiplexers: Procedure 2

- Example $F(x, y, z) = \sum(1, 2, 6, 7)$

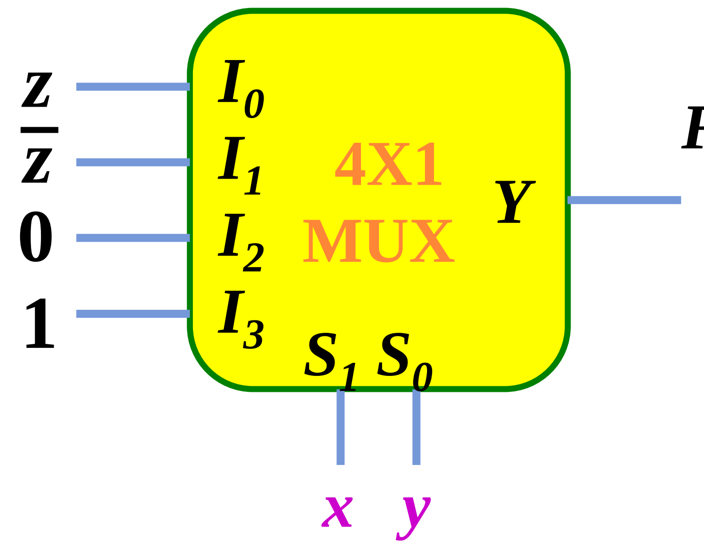
x y z	F
0 0 0	0
0 0 1	1
0 1 0	1
0 1 1	0
1 0 0	0
1 0 1	0
1 1 0	1
1 1 1	1



Implementation Using Multiplexers: Procedure 2

- $F(x, y, z) = \sum(1, 2, 6, 7)$

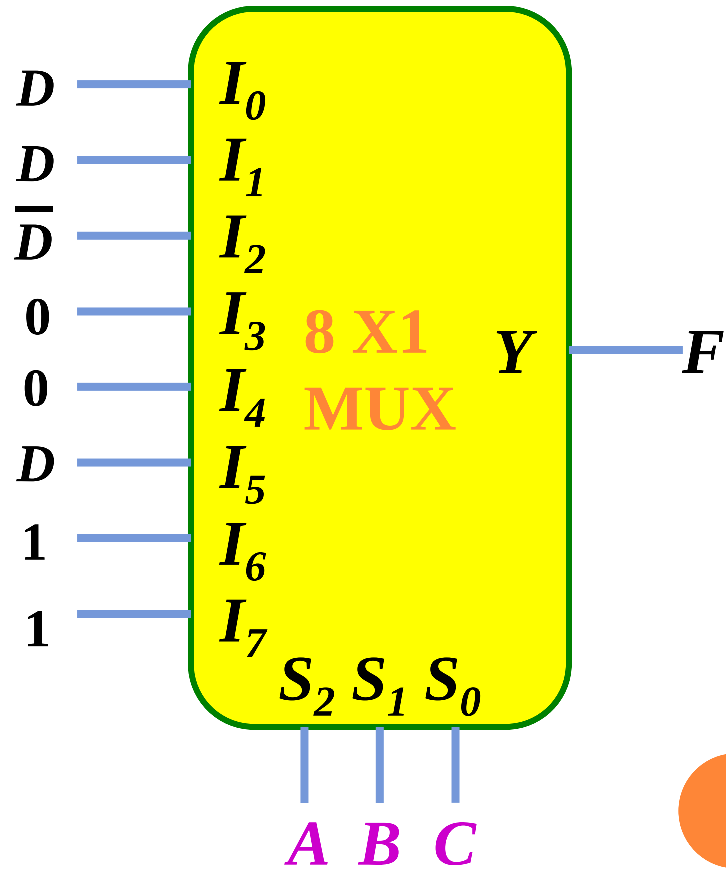
x	y	z	F	
0	0	0	0	$F = z$
0	0	1	1	
0	1	0	1	$F = \bar{z}$
0	1	1	0	
1	0	0	0	$F = 0$
1	0	1	0	
1	1	0	1	$F = z + z' = 1$
1	1	1	1	



Implementation Using Multiplexers: Procedure 2

- $F(A, B, C, D) = \sum(1, 3, 4, 11, 12, 13, 14, 15)$

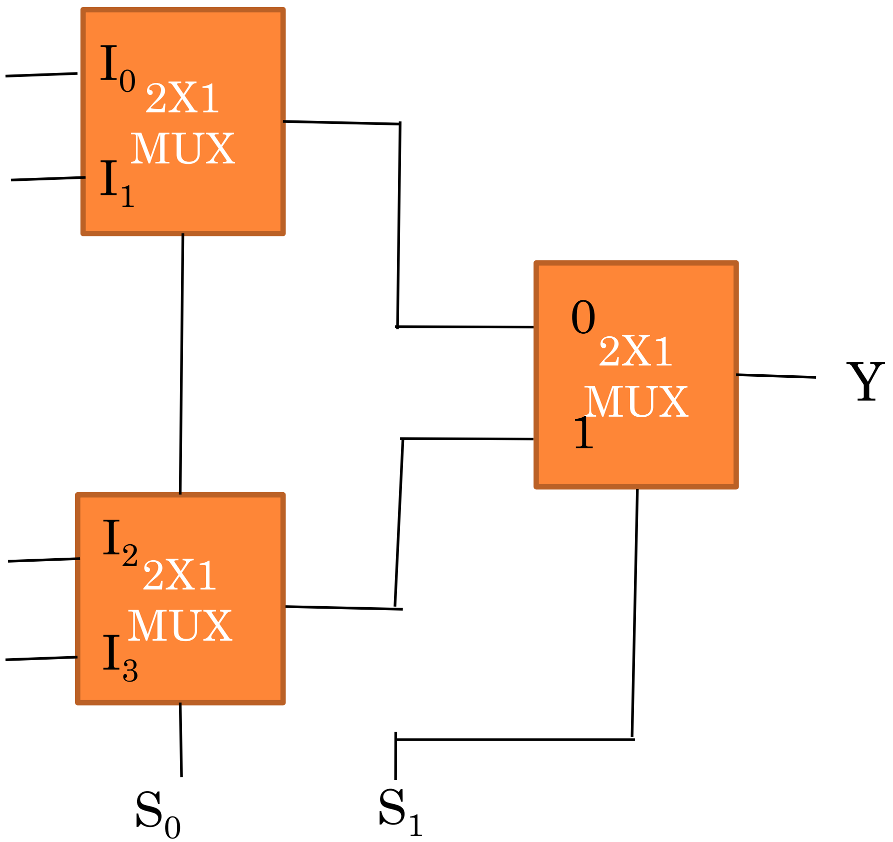
A B C D	F	
0 0 0 0	0	$F = D$
0 0 0 1	1	
0 0 1 0	0	$F = D$
0 0 1 1	1	
0 1 0 0	1	$F = \overline{D}$
0 1 0 1	0	
0 1 1 0	0	$F = 0$
0 1 1 1	0	
1 0 0 0	0	$F = 0$
1 0 0 1	0	
1 0 1 0	0	$F = D$
1 0 1 1	1	
1 1 0 0	1	$F = 1$
1 1 0 1	1	
1 1 1 0	1	$F = 1$
1 1 1 1	1	



PROCEDURE 1 VS PROCEDURE 2

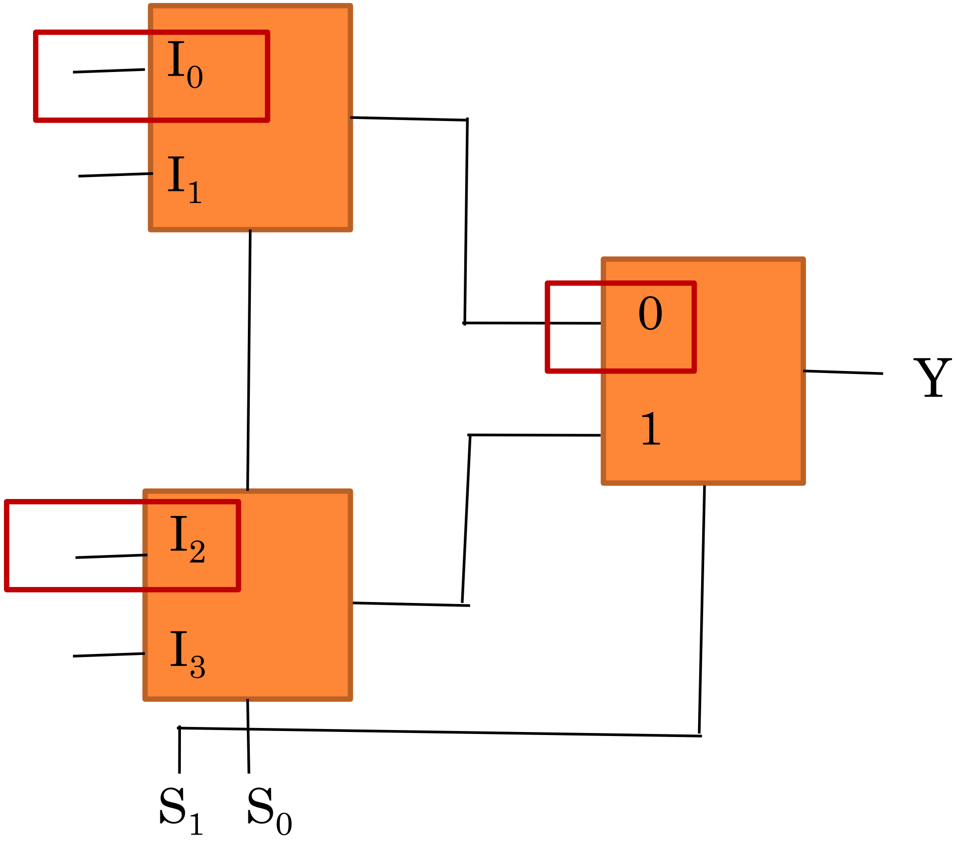
- Among the function variables, if the first or some middle variable other than the last one is to be used in input line then procedure 1 is preferable.

Multiplexer Expansion
4-to-1 MUX using 2-to-1 MUX



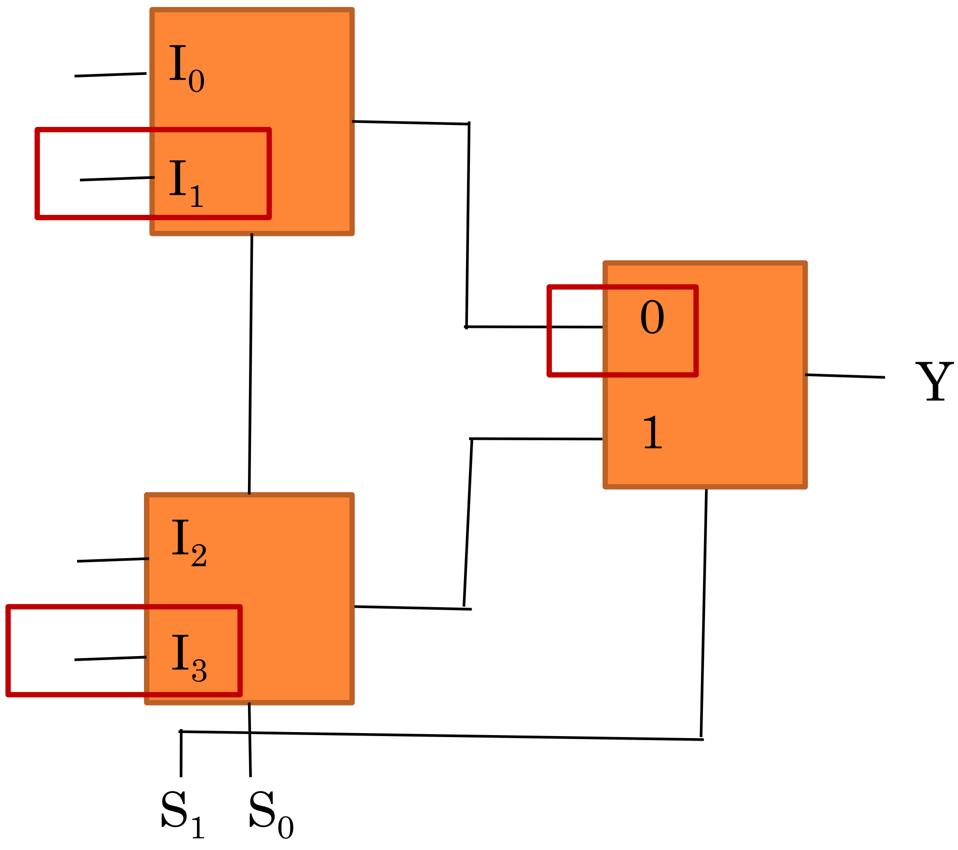
S_1	S_0	Y
0	0	I_0
0	1	I_1
1	0	I_2
1	1	I_3

Multiplexer Expansion
4-to-1 MUX using 2-to-1 MUX



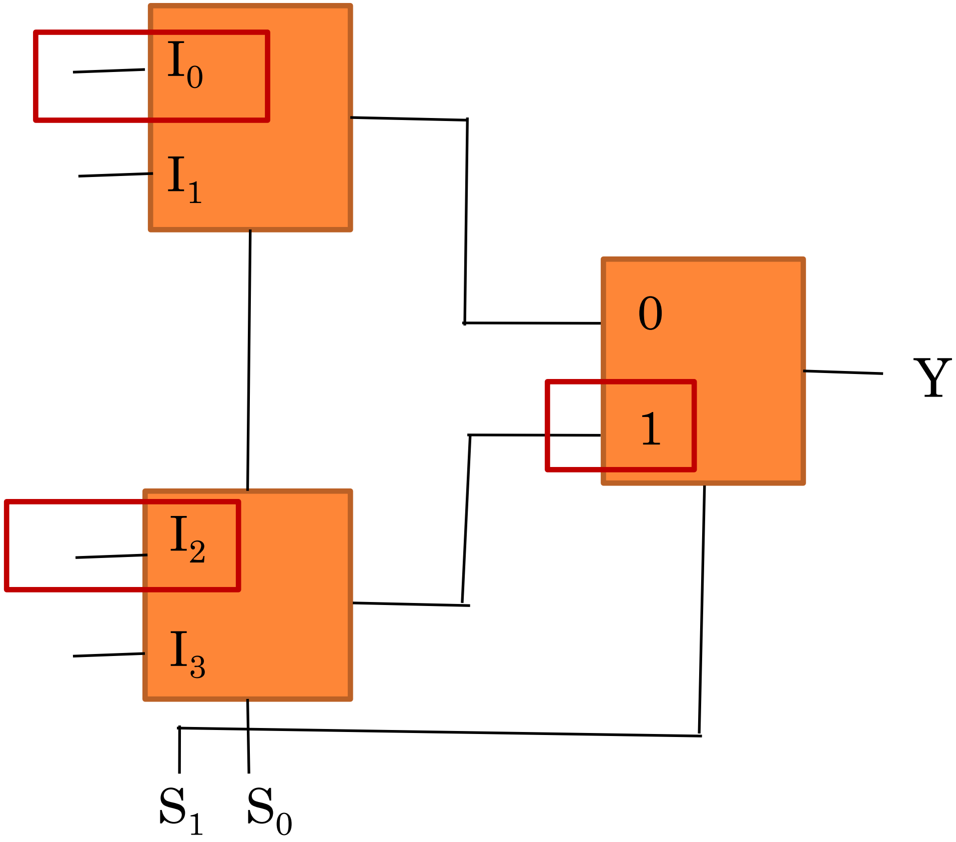
S_1	S_0	Y
0	0	I_0
0	1	I_1
1	0	I_2
1	1	I_3

Multiplexer Expansion
4-to-1 MUX using 2-to-1 MUX



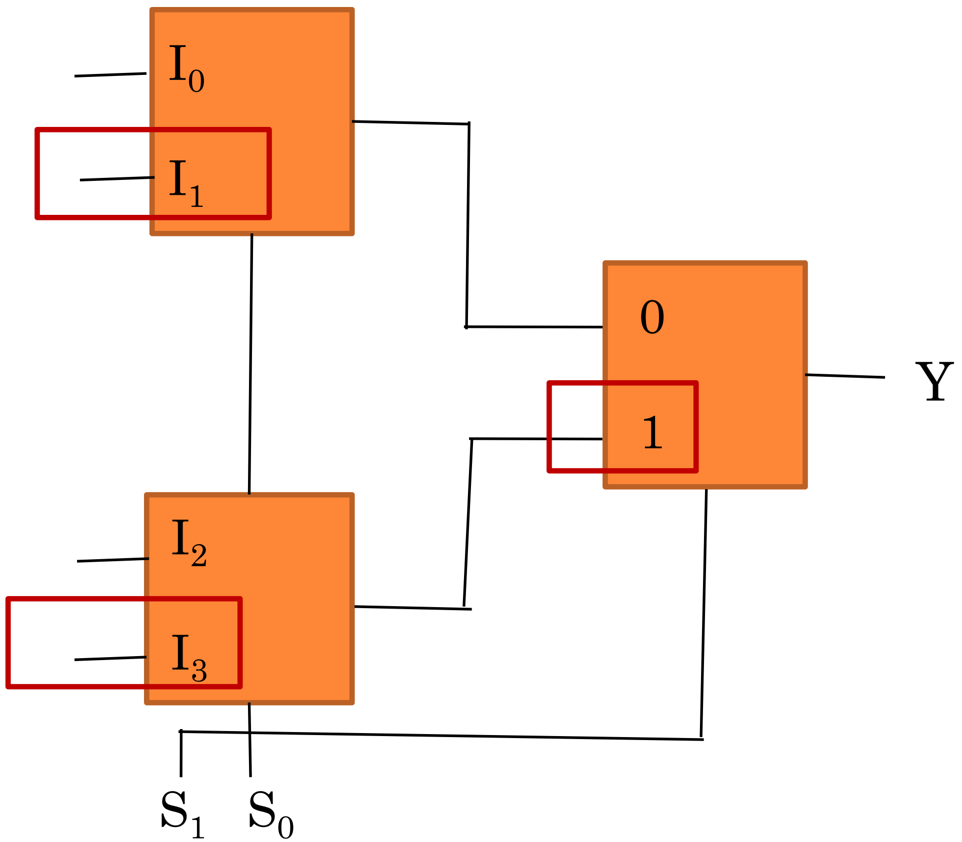
S_1	S_0	Y
0	0	I_0
0	1	I_1
1	0	I_2
1	1	I_3

Multiplexer Expansion
4-to-1 MUX using 2-to-1 MUX



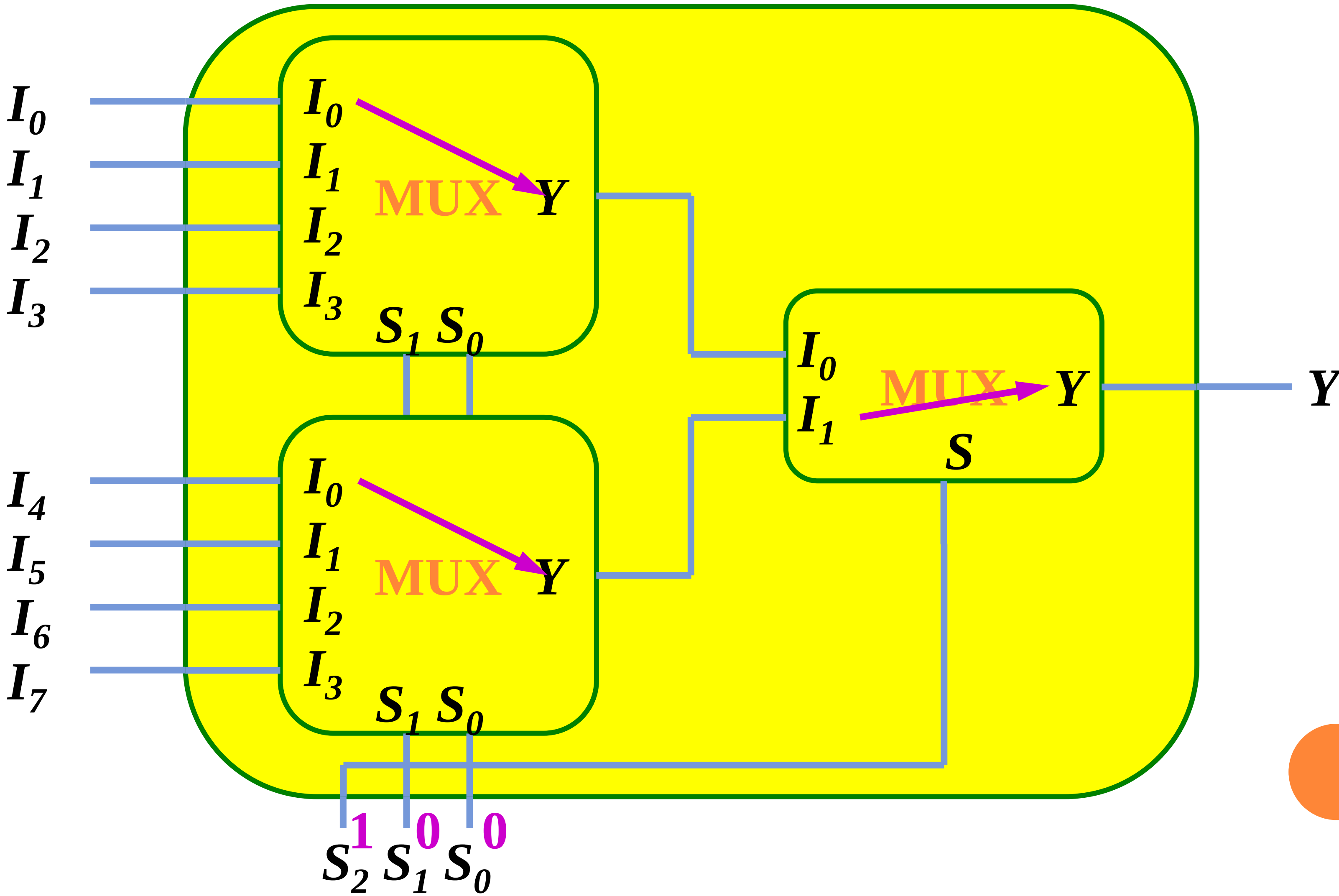
S_1	S_0	Y
0	0	I_0
0	1	I_1
1	0	I_2
1	1	I_3

Multiplexer Expansion
4-to-1 MUX using 2-to-1 MUX



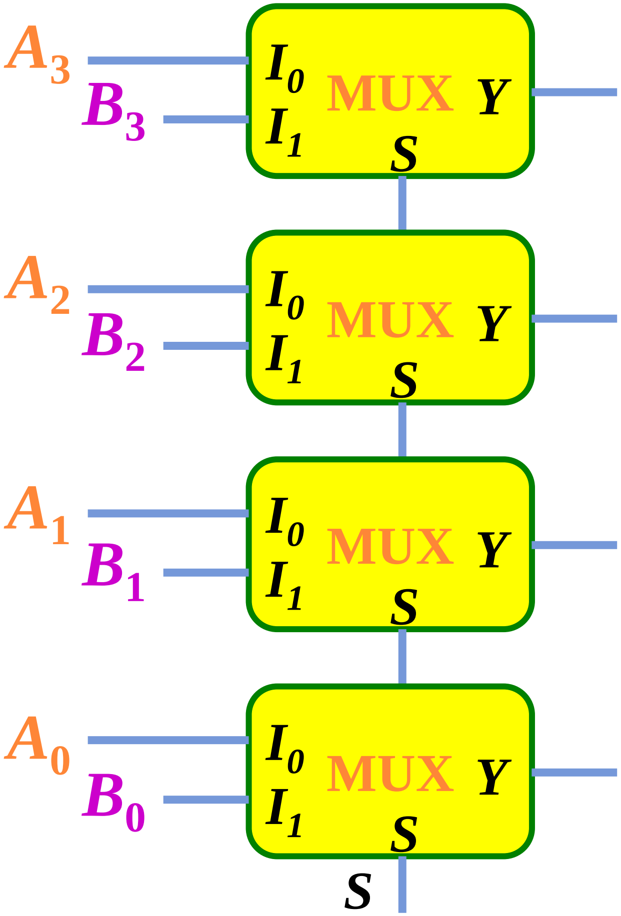
S_1	S_0	Y
0	0	I_0
0	1	I_1
1	0	I_2
1	1	I_3

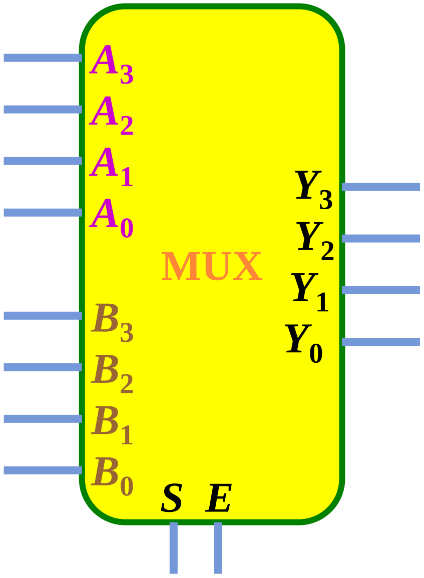
Multiplexer Expansion [Self Study]
8-to-1 MUX using Dual 4-to-1 MUX



MULTIPLEXERS

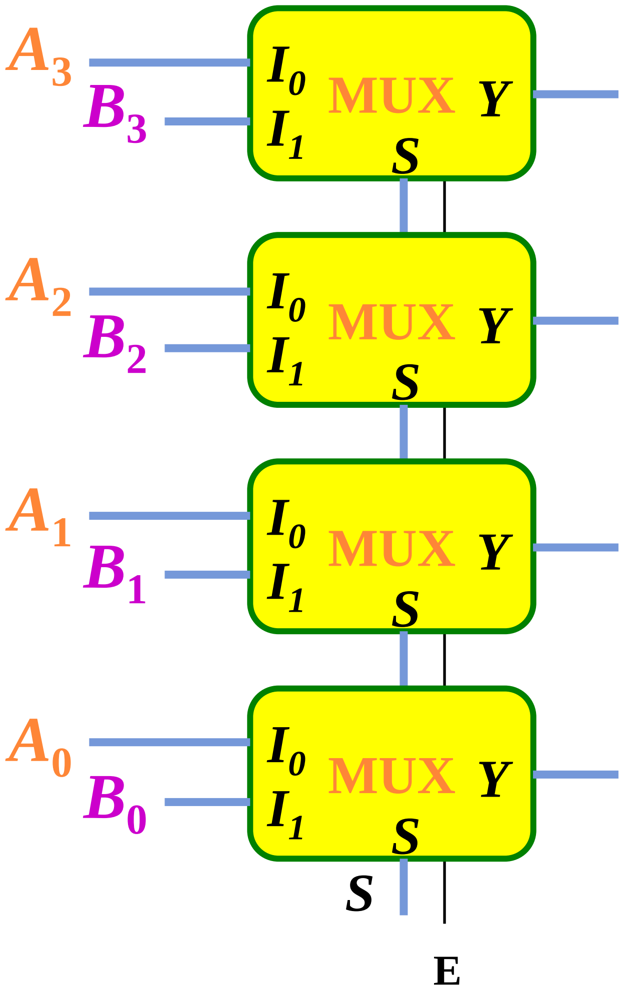
- Quad 2-to-1 MUX:
  Four 2x1 MUX can be used simultaneously

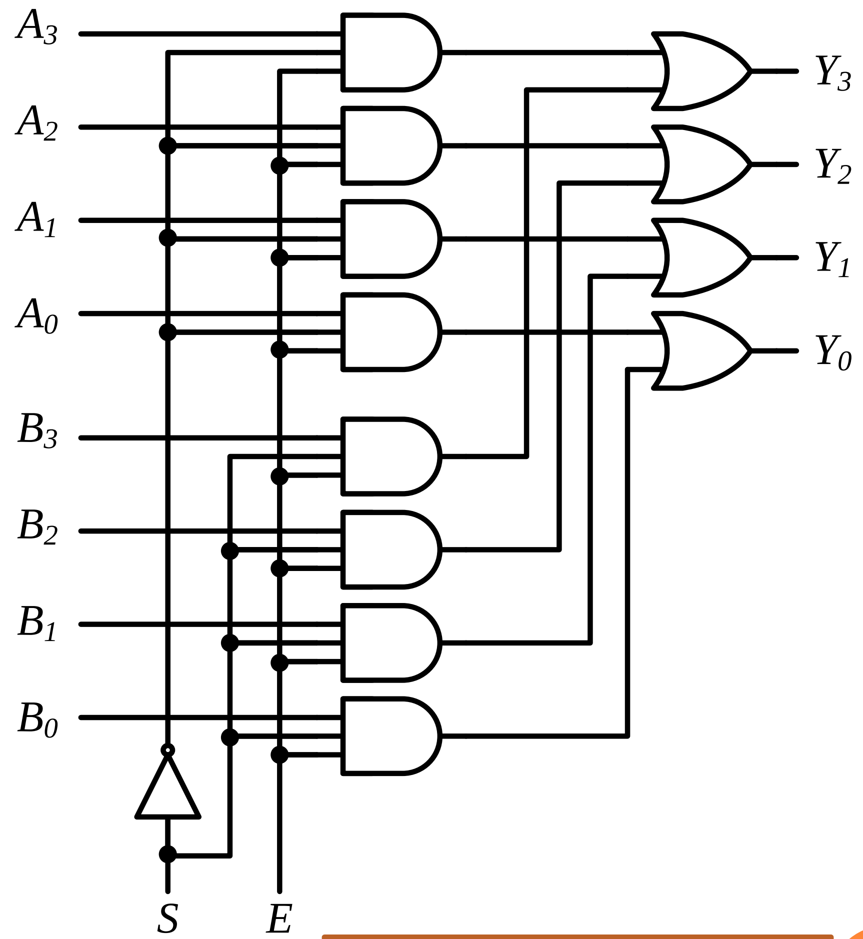




Multiplexers

- Quad 2-to-1 MUX

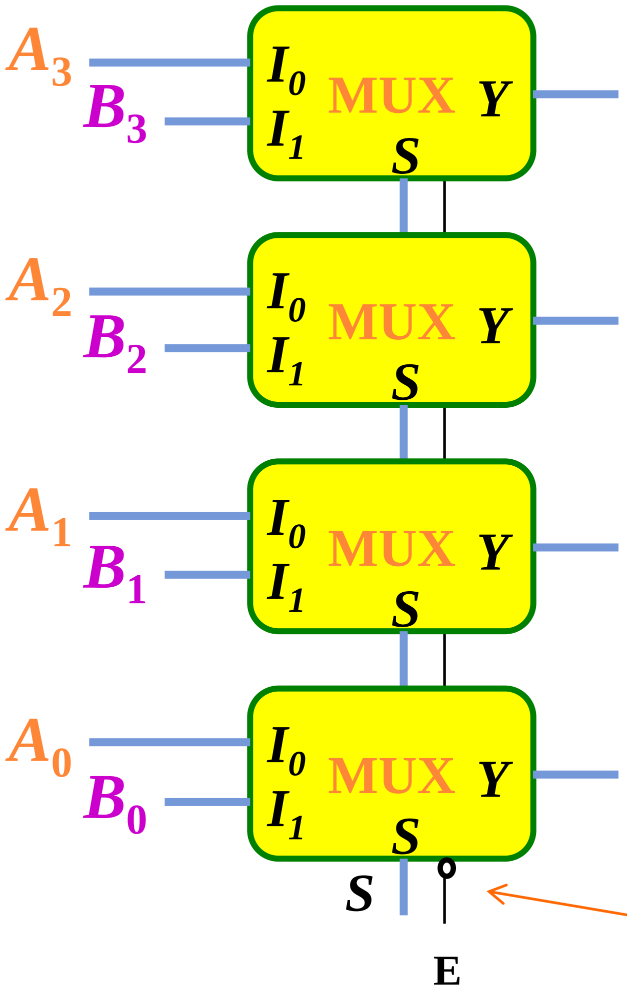


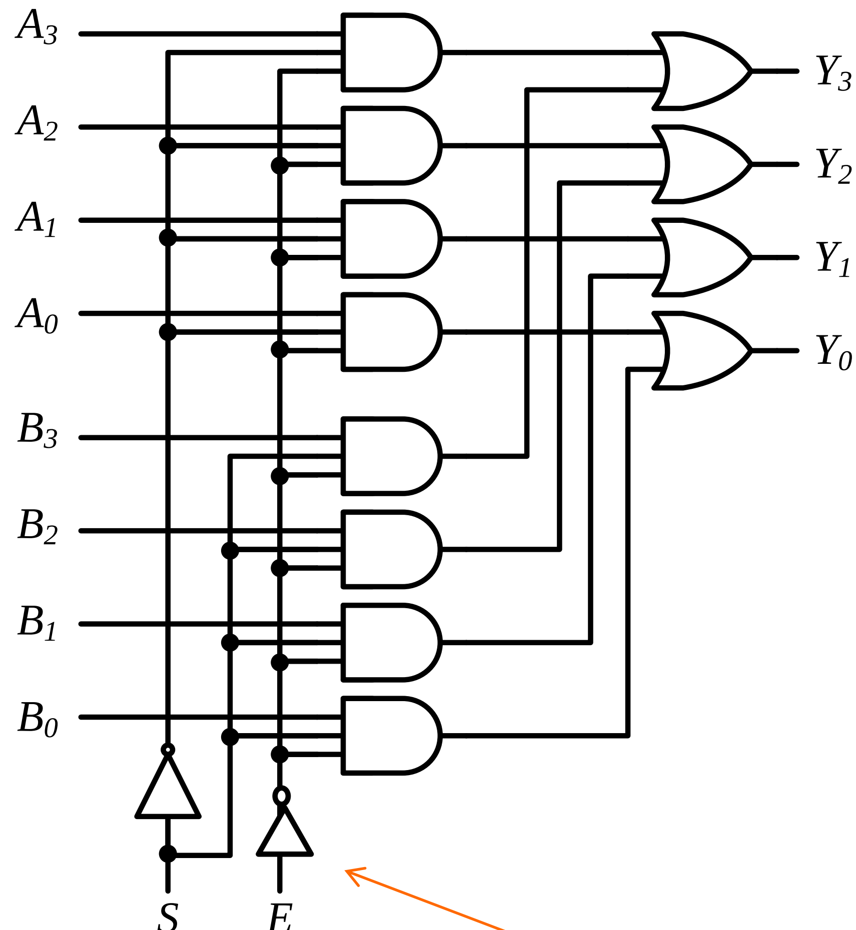


Active **High** Enable:
The output is
enabled when E=1

Multiplexers

- Quad 2-to-1 MUX





Active **Low** Enable:
The output is
enabled when E=0