

Circuits: Multiplexor

Very useful circuit for constructing CPU: $n-1$ ("n to 1") **multiplexor (MUX)**

Function: selects 1 output from n inputs

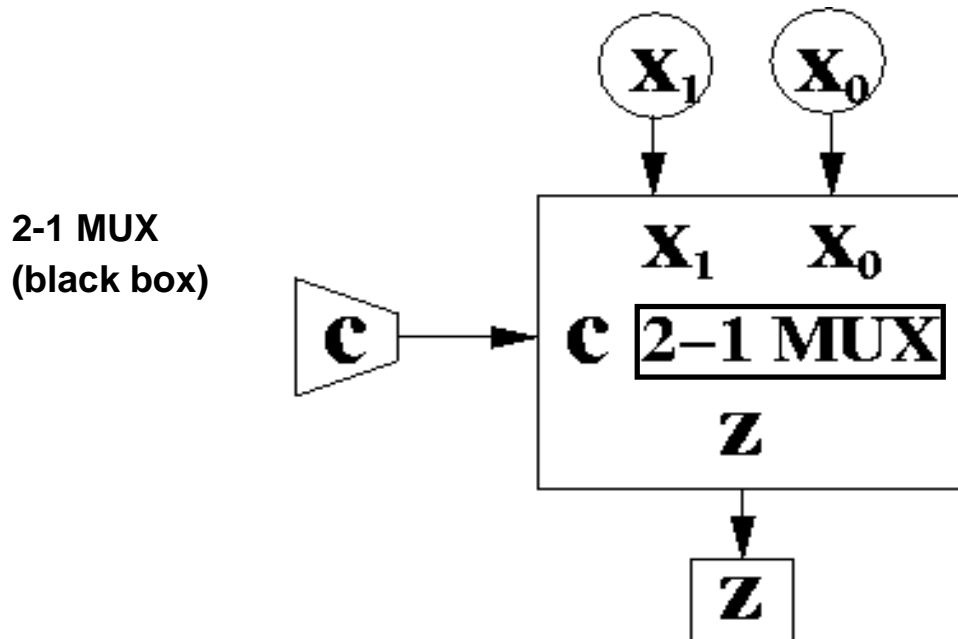
Analogy: TV remote control (select 1 channel from many inputs)

Inputs:

Data: n

Control: $\text{ceil}(\lg n)$

Output: 1



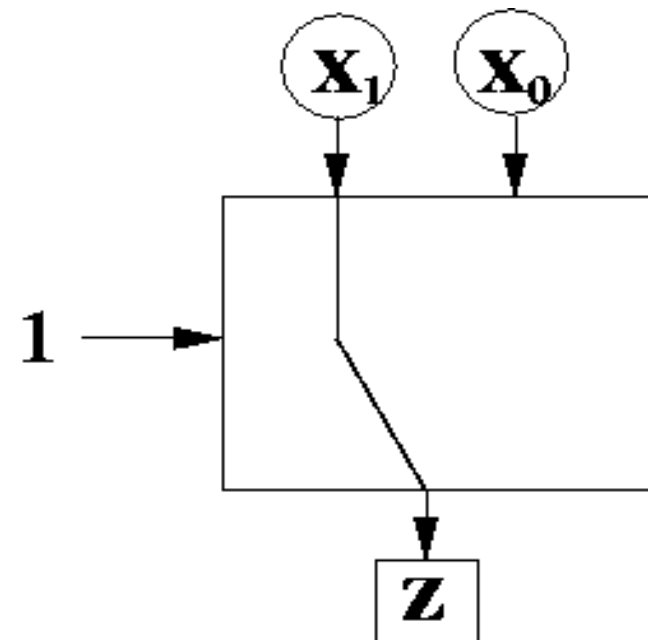
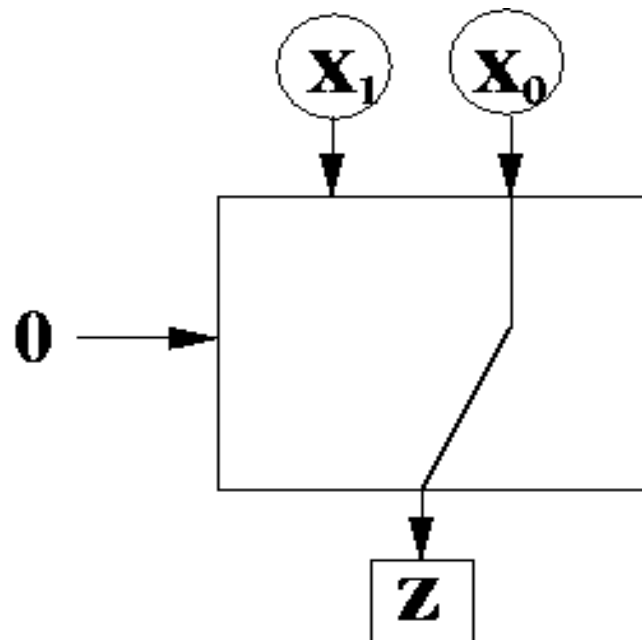
Circuits: Multiplexor

Abstract behavior:

Output is the data bit which has the same subscript as the control bit value.

$c = 0$ selects x_0

$c = 1$ selects x_1



Circuits: Multiplexor

Truth table:

c	x ₁	x ₀	z	
0	0	0	0	} Select x ₀
0	0	1	1	
0	1	0	0	
0	1	1	1	
1	0	0	0	} Select x ₁
1	0	1	0	
1	1	0	1	
1	1	1	1	

Condensed truth table:

Only control bits for input

Data bits for output

c	z
0	x ₀
1	x ₁

Boolean expression: modified rules for condensed truth table

For each row with non-zero output,

- (1) construct minterms by ANDing the input minterm with the output (which may be a variable),
- (2) then OR the minterms in the usual way

$$z = \neg c x_0 + c x_1$$

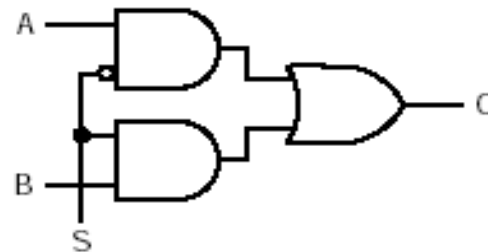
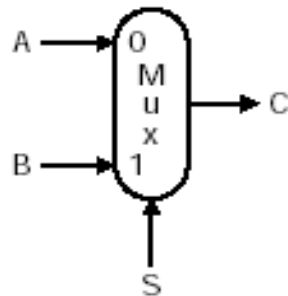
$$c == 0: z = x_0$$

$$c == 1: z = x_1$$

Circuits: Multiplexor

Implementation with gates:

Inputs: $A = x_0, B = x_1$
Control: $S = c$
Output: $C = z$



$$C = \neg SA + SB$$

(Fig. B.04)

Circuits: 4-1 Multiplexor

Inputs:

Data: 4 (x_0, x_1, x_2, x_3)

Control: $\text{ceil}(\lg n) = 2$ (c_0, c_1)

Output: 1 (z)

Condensed truth table:

Row	c_1	c_0	z
0	0	0	x_0
1	0	1	x_1
2	1	0	x_2
3	1	1	x_3

Boolean function: $z = \neg c_1 \neg c_0 x_0 + \neg c_1 c_0 x_1 + c_1 \neg c_0 x_2 + c_1 c_0 x_3$

Circuits: 4-1 Multiplexor

Boolean function: $z = \neg c_1 \neg c_0 x_0 + \neg c_1 c_0 x_1 + c_1 \neg c_0 x_2 + c_1 c_0 x_3$

Could construct this from gates, or use existing building blocks (2-1 MUX):

c1	c0	z
0	0	x_0
0	1	x_1
1	0	x_2
1	1	x_3

c_0 selects even or odd indices

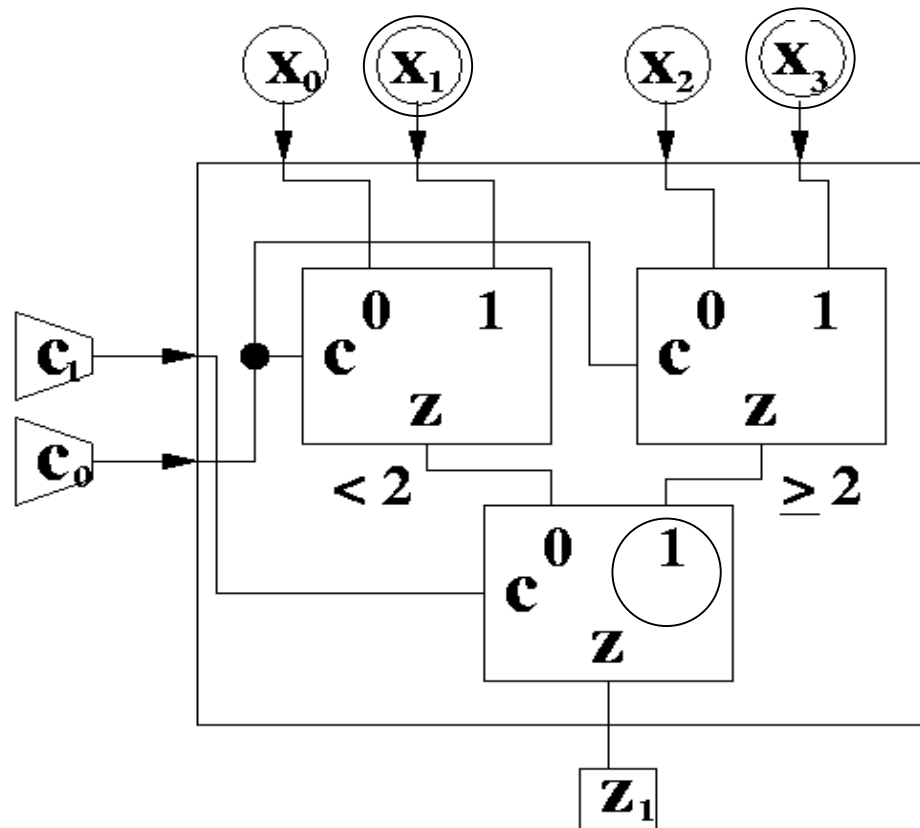
0: x_0, x_2

1: x_1, x_3

c_1 selects larger or smaller

0: x_0, x_1

1: x_2, x_3



Demultiplexor

Demultiplexor (DEMUX): MUX with input and output reversed

Analogy: mail being routed to the right box in a mailroom

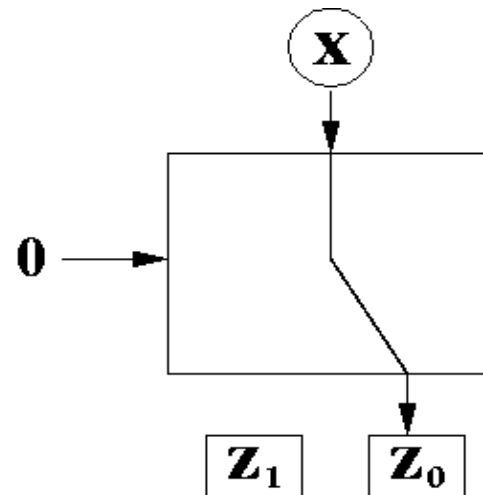
1-n DEMUX:

Data inputs: 1

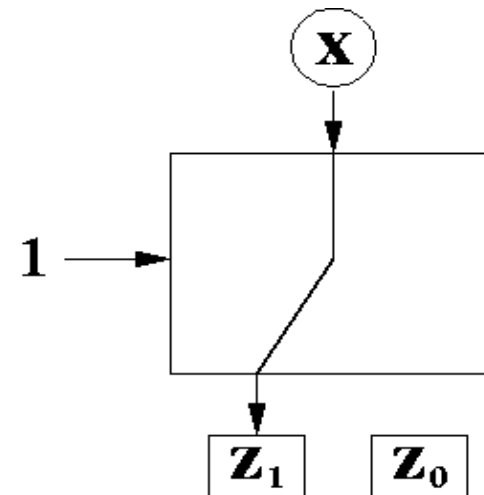
Control inputs: $\text{ceil}(\lg n)$

Outputs: n

1-2 DEMUX:



control input is 0: input goes to z_0 .



control input is 1: input goes to z_1 .

Condensed truth table:

c	z_1	z_0
0	0	x
1	x	0

$$z_0 = \neg cx$$

$$z_1 = cx$$

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