

Computer Science CSCI 355

Digital Logic and Computer Organization

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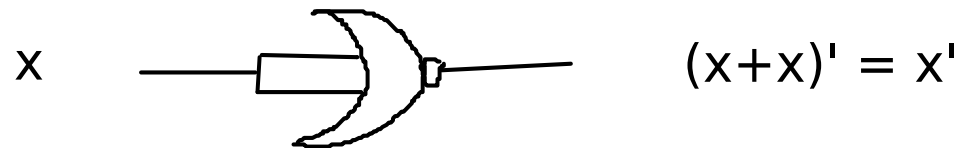
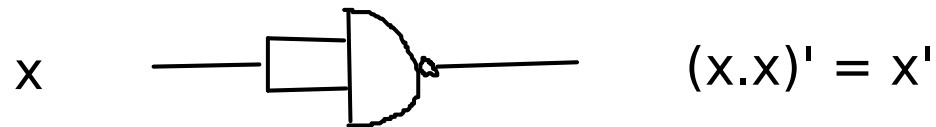
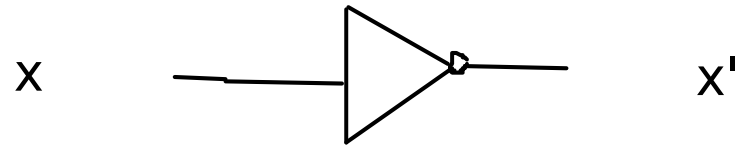
Nand/Nor Designs

○ Functionally Complete

- any valid switching equation containing operators `and`, `or` or `not` can be expressed using the `nand` operator alone
- any valid switching equation containing operators `and`, `or` or `not` can be expressed using the `nor` operator alone

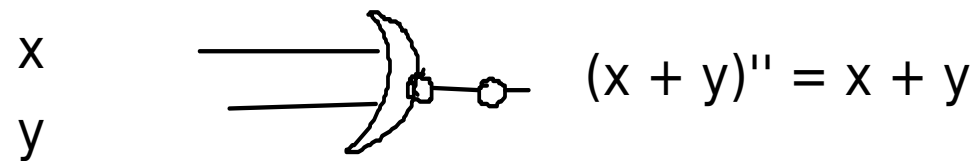
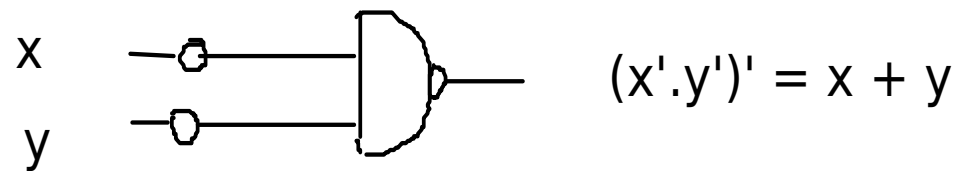
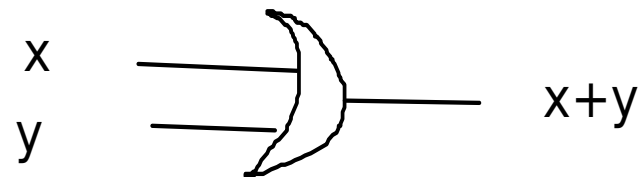
Proof (not)

○ By Construction (Perfect Induction)



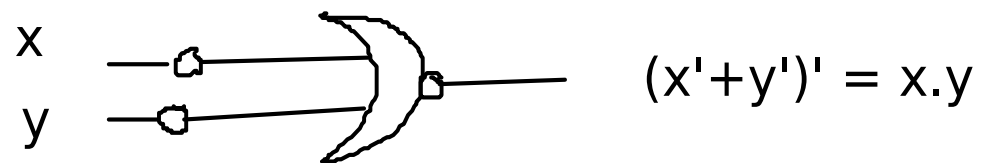
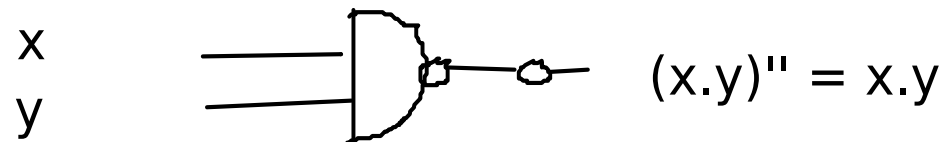
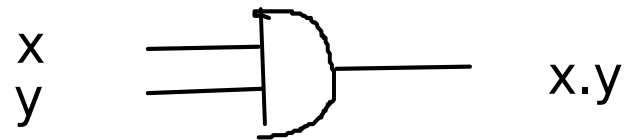
Proof (or)

○ By Construction (Perfect Induction)



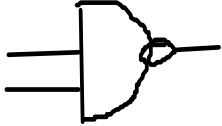
Proof (and)

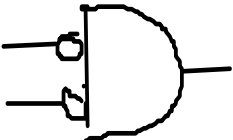
○ By Construction (Perfect Induction)

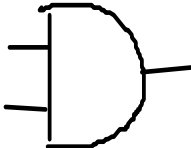



Gate Construction

Gate Type And Form

nand x  $(x.y)'$
 y

nor x  $(x'.y') = (x + y)'$
 y

and x  $x.y$
 y

or x  $(x'.y')' = x + y$
 y

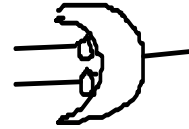
Gate Construction cont.

Gate Type

Or Form

nand

x
y



$$(x' + 'y) = (x.y)'$$

nor

x
y



$$(x + y)'$$

and

x
y



$$(x' + y')' = x.y$$

or

x
y



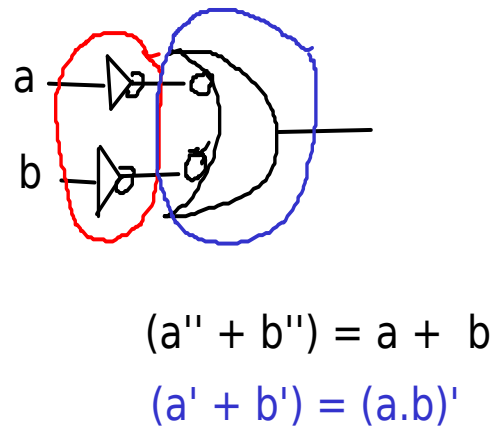
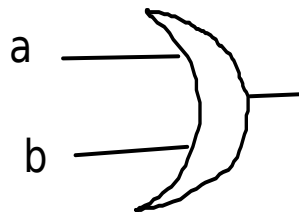
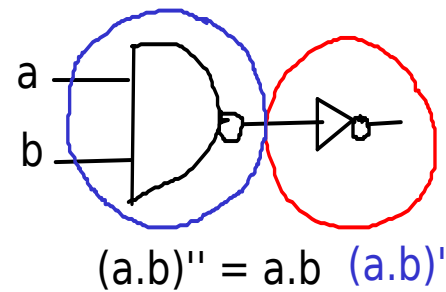
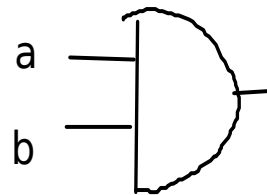
$$x + y$$

Nand Only Circuit Implementation

- Algorithm (from and, or to nand)
 - replace all and gates with and-form nand gates
 - replace all or gates with or-form nand gates
 - add inverters where bubbles don't cancel

Nand Only Circuit Implementation cont.

○ Gate Replacements

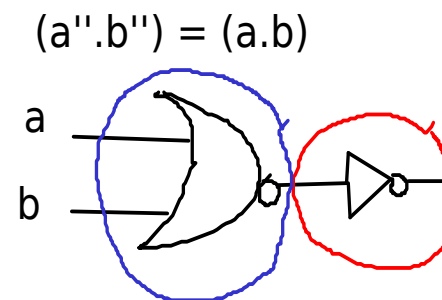
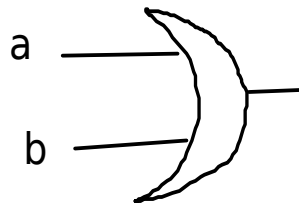
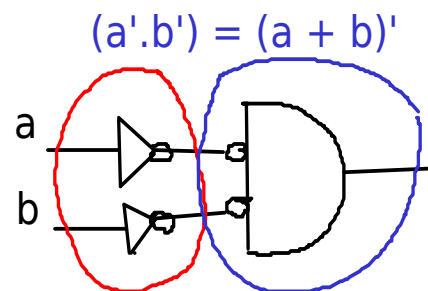
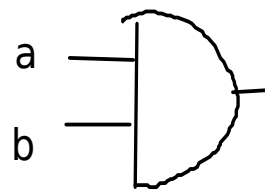


Nor Only Circuit Implementation

- Algorithm (from and, or to nor)
 - replace all and gates with and-form nor gates
 - replace all or gates with or-form nor gates
 - add inverters where bubbles don't cancel

Nor Only Circuit Implementation cont.

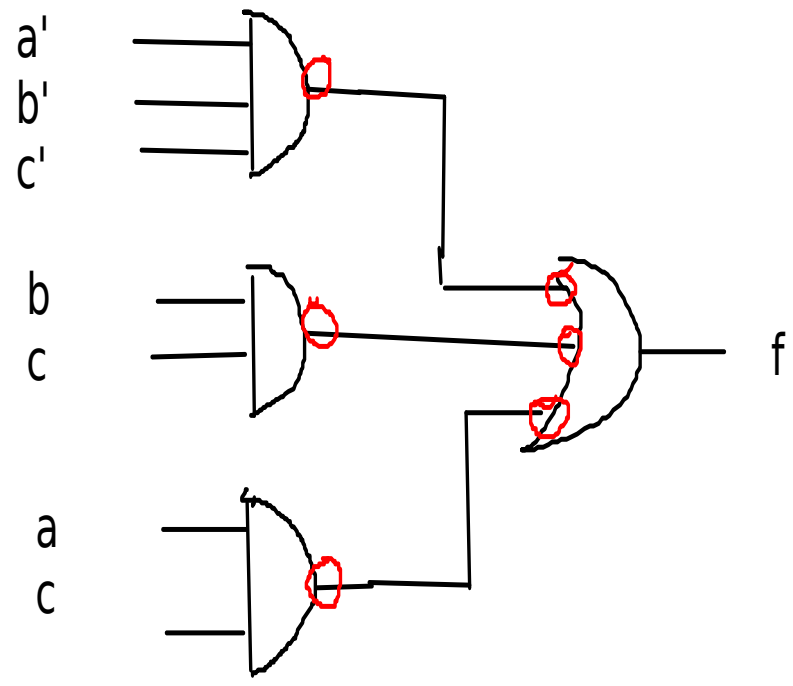
○ Gate Replacements



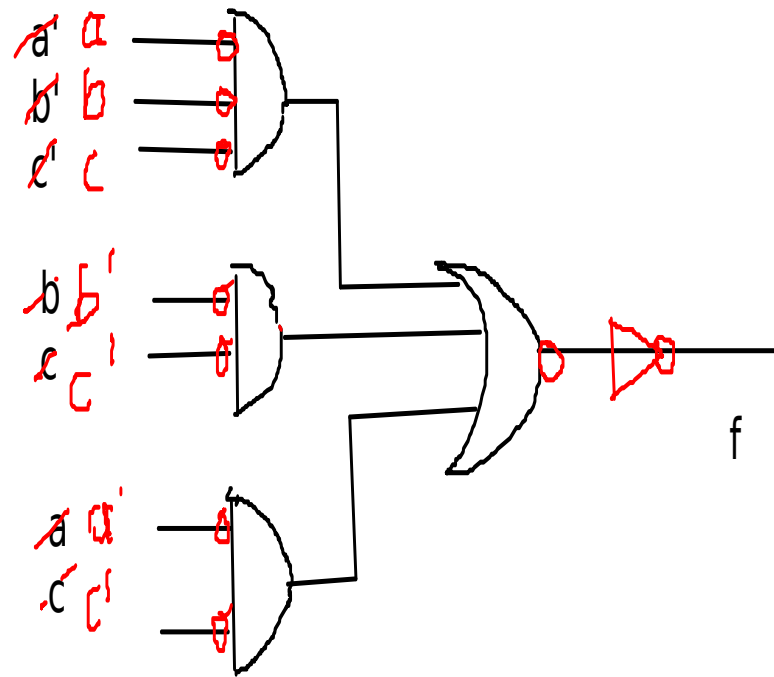
$(a + b)'' = a + b$

$(a + b)'$

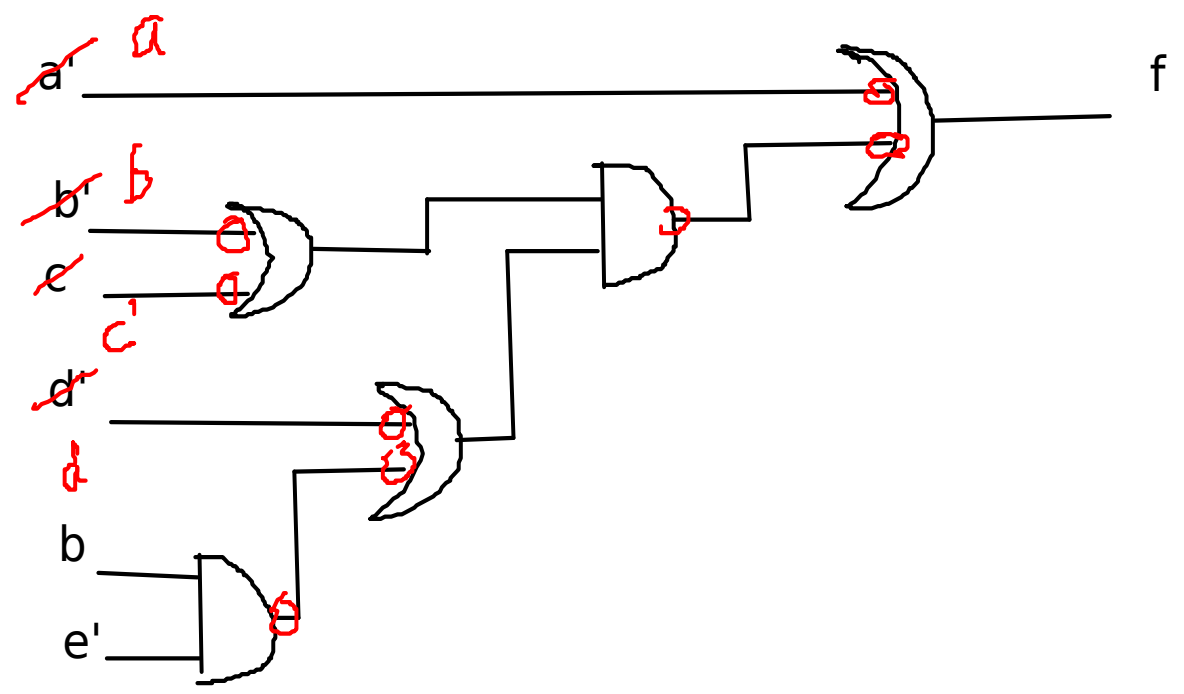
Nand Only (Two-Level)



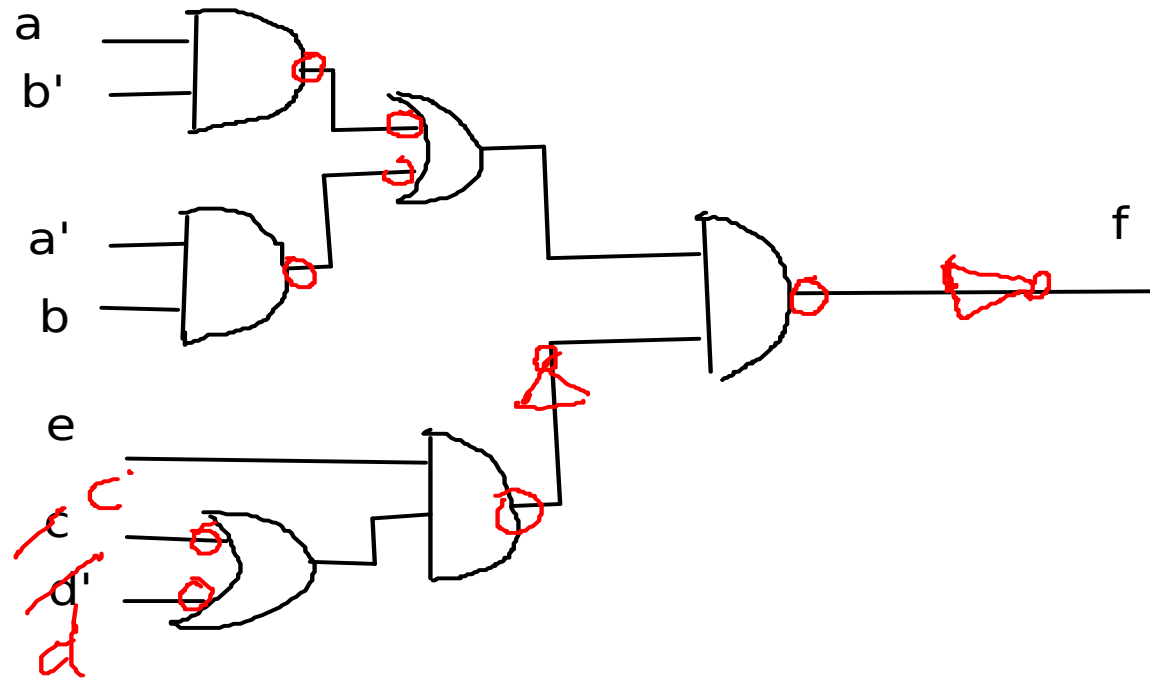
Nor Only (Two-Level)



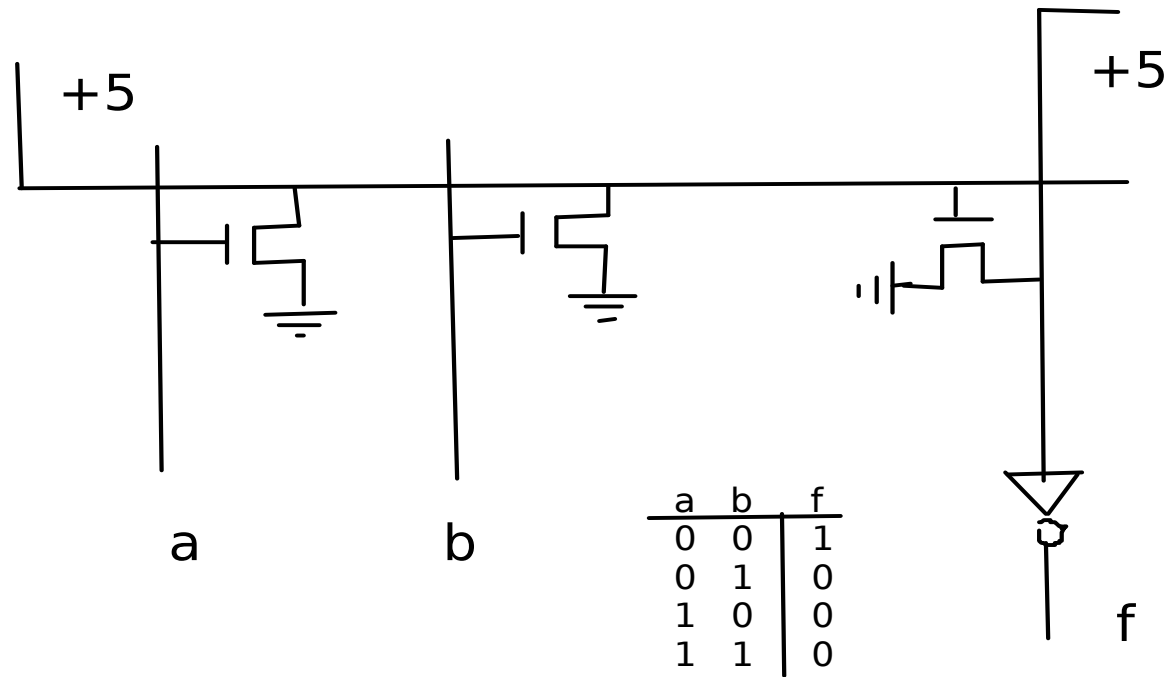
Nand Only (Multi-Level)



Nand Only (Multi-Level) cont.

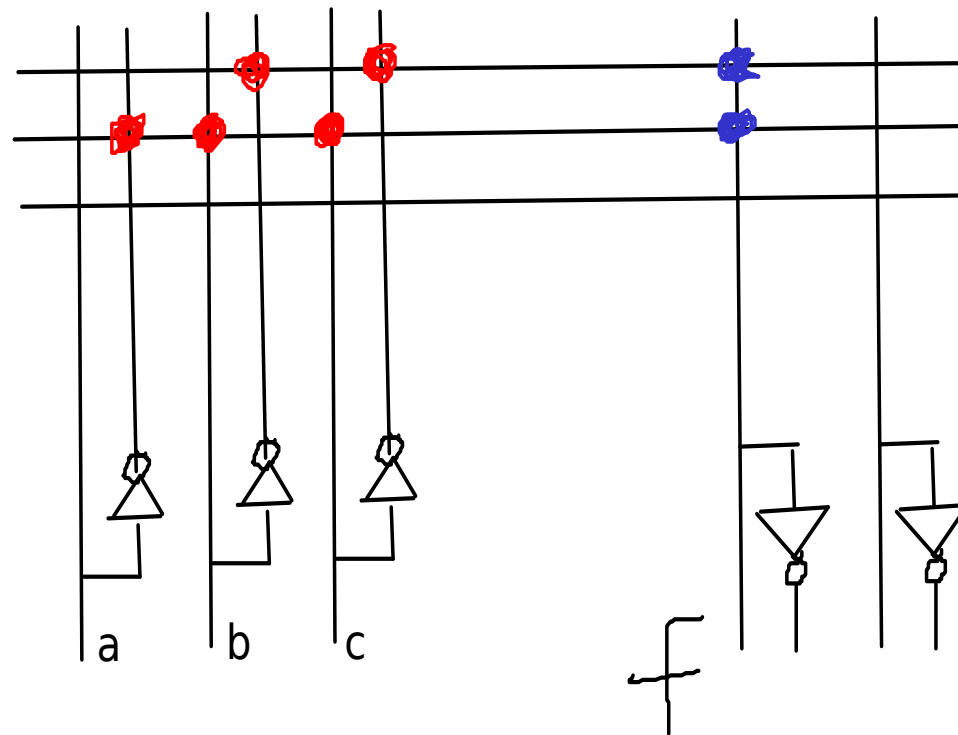


Nor-Nor Using Switches



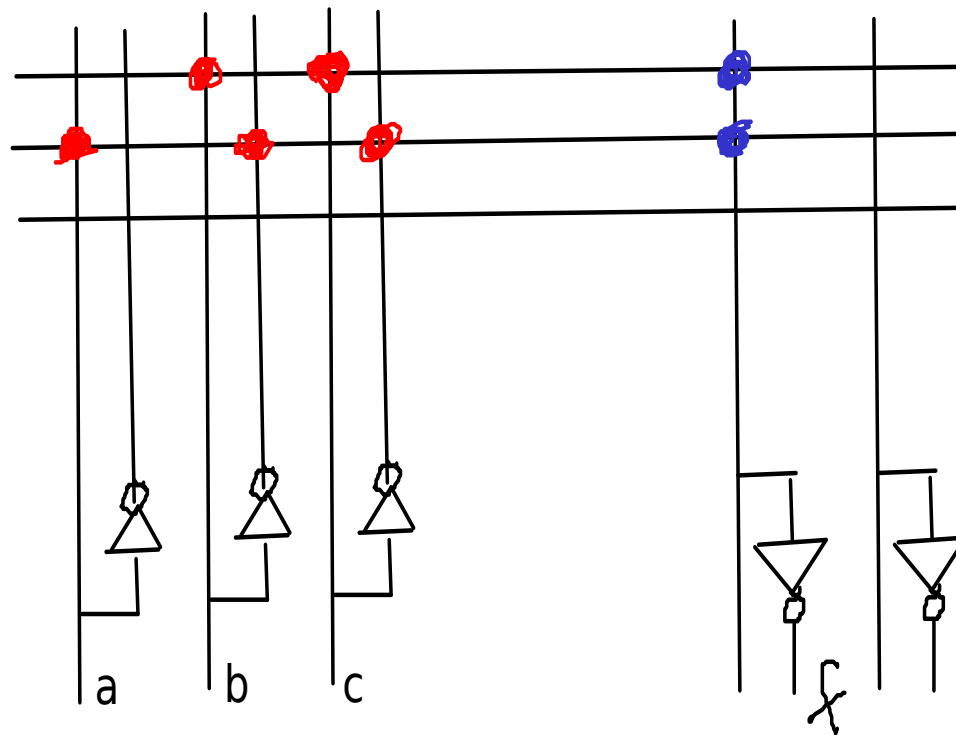
And-Or PLA

$$f = \bar{b}\bar{c} + \bar{a}bc$$



Nor-Nor PLA

$$\bigcirc f = \bar{b}\bar{c} + \bar{a}bc$$



Nand-Nand PLA

$$\bigcirc f = \bar{b}\bar{c} + \bar{a}bc$$

