ACOL 215 (29th Sept.)

Two-level implementations

AND, OR, NAND, NOR gates

Standard representation

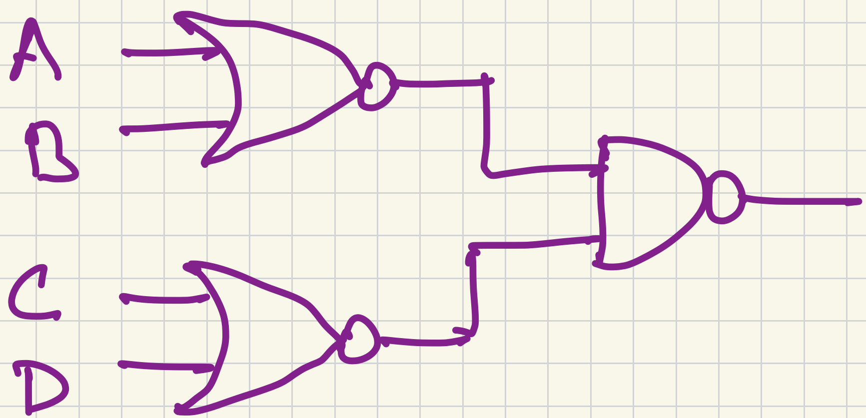
AND - OR — Sum of products

OR - AND — Product of sums

Some combinations are degenerate.

AND - AND   OR - OR

NOR - NAND (OR)



$A+B+C+D$

What about NAND - NOR ?
(AND)

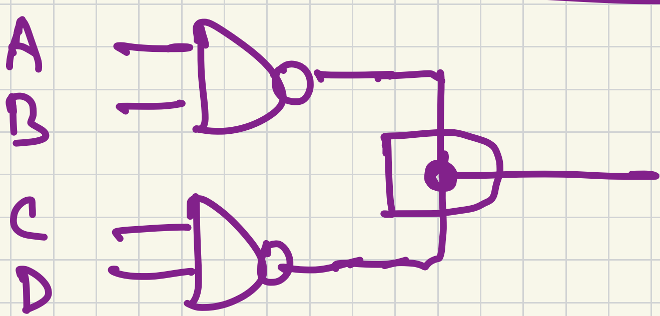
The non-degenerate forms are :

AND-OR   OR-AND

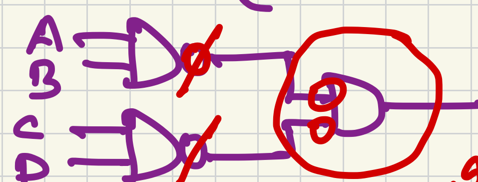
NAND-NAND   NOR-NOR   seen already

NOR-OR   NAND-AND

$\boxed{\text{OR-NAND}}$ AND-NOR

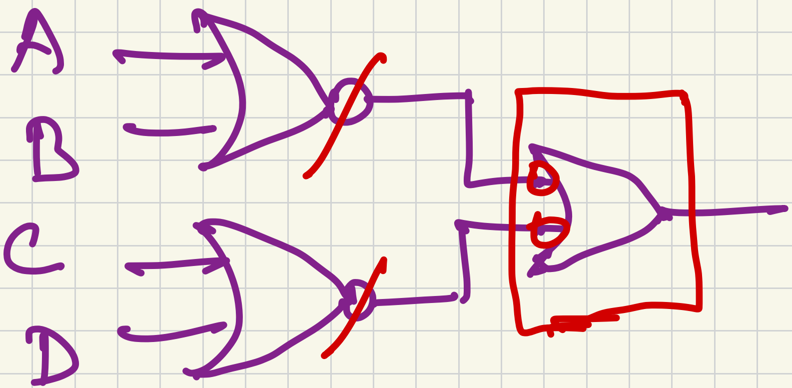


$$F = (AB + CD)'$$



NOR gate in invert-AND graphical representation

NOR-OR



$F = \left((A+B)(C+D)\right)'$

NAND gate in invert-OR graphical representation

OR-AND-Invert function

Exercise: Implement the following function with

i) AND-NOR gates ii) NAND-AND gates

iii) OR-NAND gates iv) NOR-OR gates

x \ yz	00	01	11	10
0	m_0 1	m_1 0	m_3 0	m_2 0
1	m_4 0	m_5 0	m_7 0	m_6 1

$z + xy' + x'y$

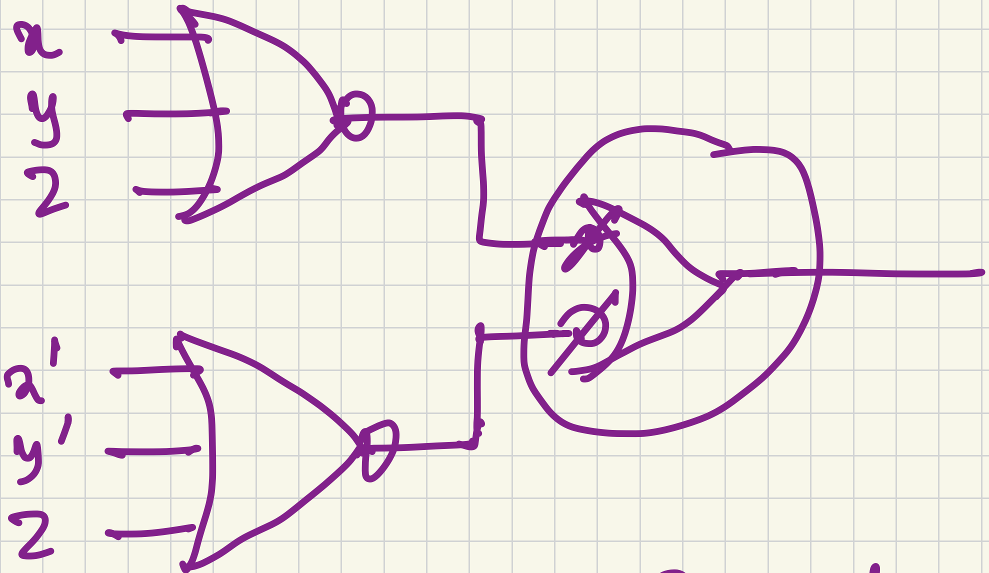
$F = x'y'z' + xyz'$

$F' = (x'y'z' + xyz')'$

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

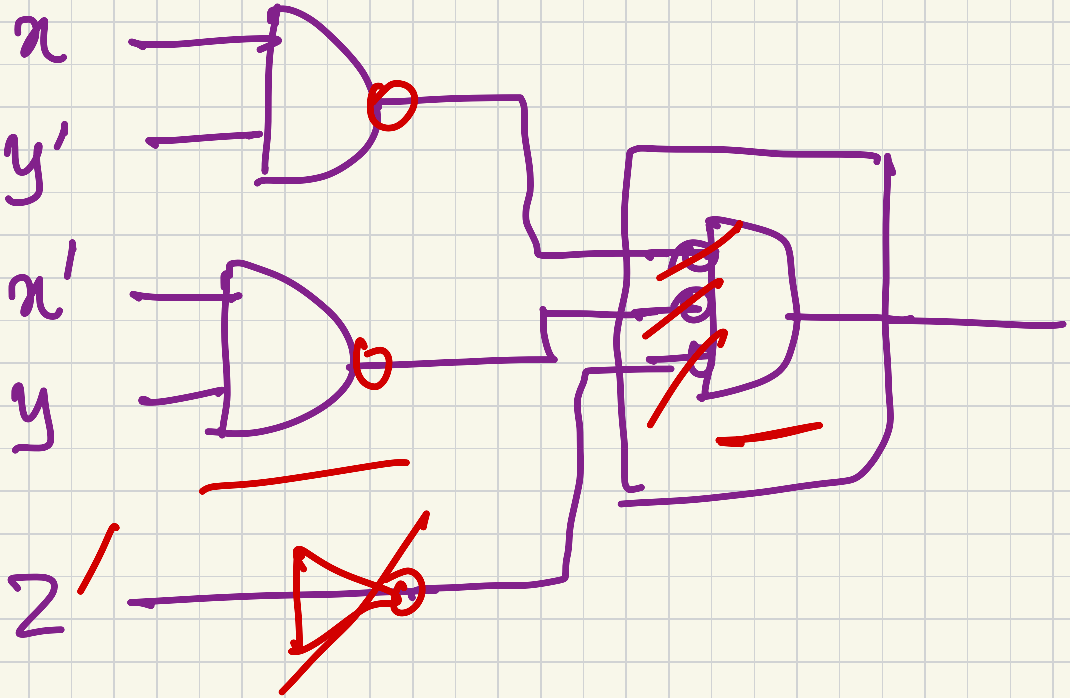
$F = ((x+y+z)(x'+y'+z))'$

$$((x+y+z)(x'+y'+z))'$$



$$f = (xy' + x'y + z)'$$

$(xy' + x'y + z)'$

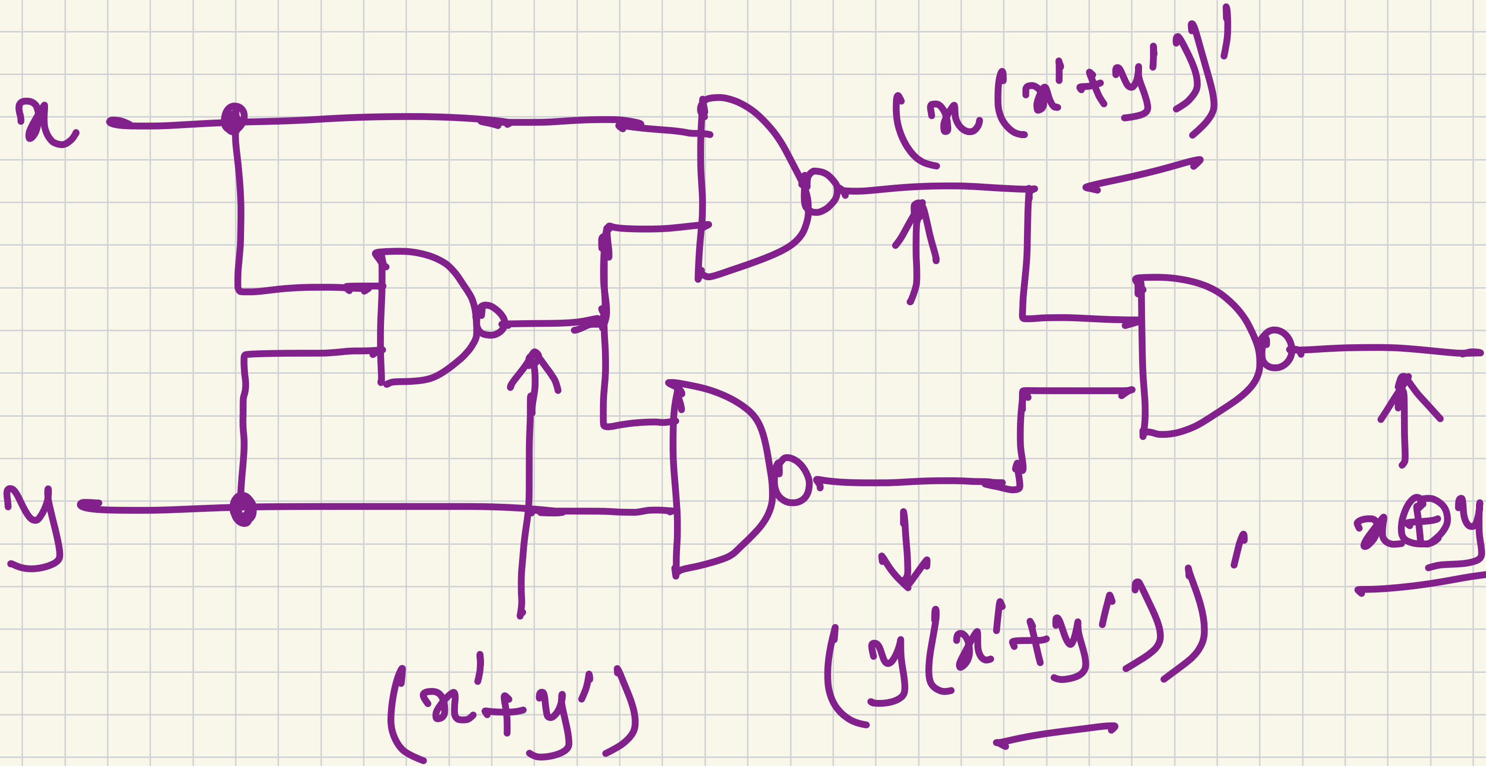


XOR gates (Exclusive -OR gates) $\oplus$

$$x \oplus y = xy' + x'y$$

Exclusive -NOR (XNOR)

$$(x \oplus y)' = xy + x'y'$$



$$x(x'+y') + y(x'+y')$$
$$= xx' + xy' + yx' + yy' = xy' + x'y$$

$x \oplus y$

$x \backslash yz$	00	01	11	10
0	m_0 1	m_1 1	m_3 1	m_2 1
1	m_4 1	m_5 1	m_7 1	m_6 1

even

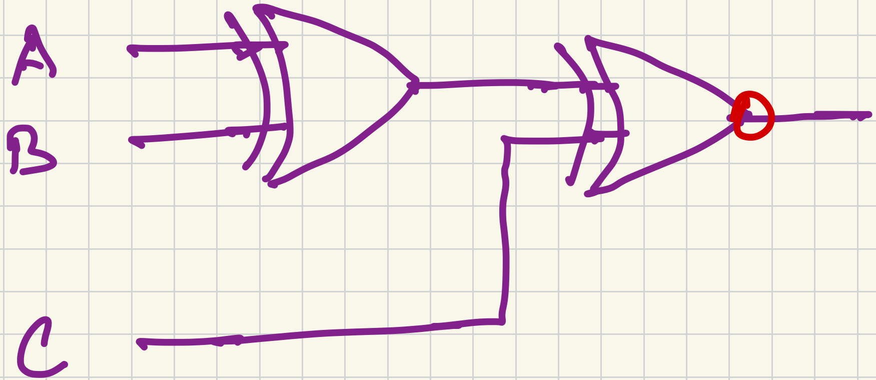
$x \oplus y \oplus z$

can be extended to multiple inputs (both commutative and associative)

$\boxed{x \oplus y \oplus z}$ odd

$= (xy' + x'y)z' + (xy' + x'y)'z$

$= xy'z' + x'yz' + xyz + x'y'z$



3- input odd function

even

Parity generation and checking

XOR functions are useful in systems requiring error detection and correction.

A parity bit is an extra bit included with a binary string (message) to make the number of 1's either even or odd.

Even parity bit generator (for a 3-bit message)

x	y	z	P
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

$$P = x \oplus y \oplus z$$

Parity checker

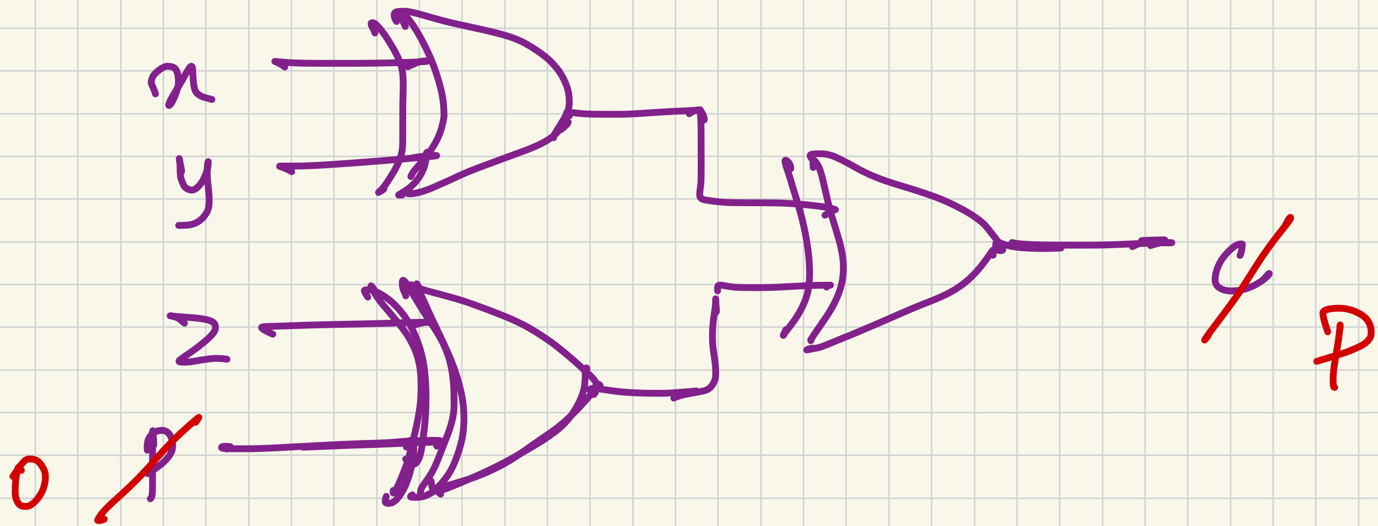
$x \quad y \quad z \qquad P$

$\underbrace{\hspace{6cm}}_{\text{even no. of 1's}}$

$\underbrace{\hspace{6cm}}_{\text{odd no. of 1's}}$

C	
0	(no error)
1	(error)

$$C = x \oplus y \oplus z \oplus P$$



$z \oplus 0 = z$

Chapter 4 — Combinational and Sequential circuits || storage element

Exercise — Read sect. 3.9 and 3.10 HDL