COL215L: Digital Logic & System Design

Lecture 6: Combinational Circuits

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Notation

AND — $\cdot$

OR — $+$

NOT — $'$

$x \rightarrow$ Input

$y \rightarrow$ Input

$f \rightarrow$ output

$f = x \cdot y$

$f = x + y$

x' $\quad$ $\overline{x}$

Truth Table

x	y	f
0	0	0
0	1	1
1	0	1
1	1	1

$f = x + y$

Number of Distinct Functions

n – inputs

1 – output

2 - inputs, x, y

1 – output, f

x	y	f
0	0	0, 1
0	1	0, 1
1	0	0, 1
1	1	0, 1

$2^{2^2} = 16$

$2^{2^{n}}$, $n=2$ – 16

$n=3$, 256

$n=4$, 65536

Universal Gate Set

{AND, OR, NOT} →

{NAND}

{NOR}

x, y, z

$f = x \cdot y + z$

x	y	z	f
0	0	0	1
1	0	1	1

$f = x' \cdot y' \cdot z'$

$+ x \cdot y' \cdot z$

DeMorgan’s Laws

- $(a + b)' = a'.b'$ ①
- $(a.b)' = a' + b'$ ②

{NAND}

$+, \cdot, '$

$f_1 = (a+b)'$

$f_2 = a'.b'$

$f_1 = f_2$

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

$= a + (b' + c')'$ {Law-2}

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

$= ((a + bc)')' = (a'.(bc)')'$

$((a')' + ((bc)')')'$

Duality

- Replace AND with OR
- Replace OR with AND

$$(a+b+c')\cdot d = a\cdot d + b\cdot d + c'\cdot d$$

$$\boxed{a\cdot b\cdot c' + d} = \boxed{(a+d)\cdot(b+d)\cdot(c'+d)}$$