January 8, 2026

Base 2, 8, 16

Binary $(\overset{7}{1}\overset{6}{1}\overset{5}{1}\overset{4}{1}\overset{3}{1}\overset{2}{1}\overset{1}{1}\overset{0}{1})_2 \to (\quad)_{10}$

$$1\cdot 2^7 + 1\cdot 2^6 + 1\cdot 2^5 + 1\cdot 2^4 + 1\cdot 2^3 + 1\cdot 2^2 + 1\cdot 2^1 + 1\cdot 2^0$$

$$= 128 + 64 + 32 + 16 + 8 + 4 + 2 + 1 =$$

$$= 255_{10}$$

$$(\overset{2}{3}\overset{1}{7}\overset{0}{7})_8 = 3\cdot 8^2 + 7\cdot 8^1 + 7\cdot 8^0 = 255_{10}$$

$$(\overset{1}{F}\overset{0}{F})_{16} \to (\quad)_{10}$$

base 16:

$$16^{1} \cdot F + 16^{0} \cdot F = 16 \cdot 15 + 15 = 255_{10}$$

Decimal

$$\begin{tikzcd} & (\quad)_2 \\ (\qquad)_{10} \arrow[ur] \arrow[r] \arrow[dr] & (\quad)_8 \\ & (\quad)_{16} \end{tikzcd}$$

HEX

10	A
11	B
12	C
13	D
14	E
15	F

$$\begin{array}{r|l} 255 & 2 \\ \hline 254 & 127 \\ 1 & \end{array} \quad \begin{array}{r|l} 127 & 2 \\ \hline 126 & 63 \\ 1 & \end{array} \quad \begin{array}{r|l} 63 & 2 \\ \hline 62 & 31 \\ 1 & \end{array} \quad \begin{array}{r|l} 31 & 2 \\ \hline 30 & 15 \\ 1 & \end{array} \quad \begin{array}{r|l} 15 & 2 \\ \hline 14 & 7 \\ 1 & \end{array} \quad \begin{array}{r|l} 7 & 2 \\ \hline 6 & 3 \\ 1 & \end{array} \quad \begin{array}{r|l} 3 & 2 \\ \hline 2 & 1 \\ 1 & \end{array}$$

$$255_{10} = 11111111_2$$

114_{10}

$$
\begin{array}{l}
114 \,|\, 2 \\
114 \,|\, 57 \,|\, 2 \\
\quad 0 \quad 56 \,|\, 28 \,|\, 2 \\
\qquad 1 \quad 28 \,|\, 14 \,|\, 2 \\
\qquad\quad 0 \quad 14 \,|\, 7 \,|\, 2 \\
\qquad\qquad 0 \quad 6 \,|\, 3 \,|\, 2 \\
\qquad\qquad\quad 1 \quad 2 \,|\, 1 \\
\qquad\qquad\qquad 1
\end{array}
$$

1110010_2

$$(0.12)_{10} \to (\quad)_2 = (.000111)_2$$

$0.12 \times 2 = \underbrace{0}.24$	0	just fraction
$0.24 \times 2 = \underbrace{0}.48$	0	
$0.48 \times 2 = \underbrace{0}.96$	0	
$0.96 \times 2 = 1\underbrace{.92}$	1	
$0.92 \times 2 = 1\underbrace{.84}$	1	
$0.84 \times 2 = 1.68$	1	

Dec.	Binary	Hex.	Dec.	Binary
1	0001		9	1001
2	0010	A	10	1010
3	0011	B	11	1011
4	0100	C	12	1100
5	0101	D	13	1101
6	0110	E	14	1110
7	0111	F	15	1111
8	1000			

Binary addition

$$
\begin{array}{r}
+\ 01100 \\
10001 \\
\hline
11101
\end{array}
$$

$$
\begin{array}{r}
{}^{1}\ \ {}^{1}\ \ {}^{1}\ \ \ \ \\
+\ 1\,0\,1\,1\,0 \\
1\,0\,1\,1\,1 \\
\hline
\underbrace{1}\,[0\,1\,1\,0\,1]
\end{array}
$$

$(1)_2 + (1)_2 = (10)_2$

$(10)_2 + (1)_2 = (11)_2$

It is overflow, machine should know that It is overflow

Binary subtraction

$$
\begin{array}{r} 0 \\ -\,0 \\ \hline 0 \end{array}
\qquad
\begin{array}{r} 1 \\ -\,1 \\ \hline 0 \end{array}
\qquad
\begin{array}{r} 1 \\ -\,0 \\ \hline 1 \end{array}
\qquad
\begin{array}{r} {}^{1\leftarrow}\ 0 \\ -\,1 \\ \hline 1 \end{array}
$$

$$
\begin{array}{r} 10110 \\ -\,10010 \\ \hline 00100 \end{array}
\qquad
\begin{array}{r} 10110 \\ -\,10011 \\ \hline 00011 \end{array}
$$

1's complement

$(10101111)_2$ logic operation

1's compliment is inverse of digits

(01010000) 1's comp.
$+\ 1$

(01010001) 2's compliment

$(0101)_2 = (5)_{10}$

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$(r-1)$'s r's compliments

radix = base

$r = 10 \quad L = 4 \quad N = 2468 \quad r^4 = 10000$

$r^4 - 1 = 9999$

Therefore

$$\begin{array}{r} 9999 \\ -\,2468 \\ \hline 7531 \end{array}$$

Decimal $(185)_{10}$

Binary $(10111001)_2$

Binary Coded Decimal BCD

$(459)_{10} \rightarrow (\quad)_{BCD}$

0100 0101 1001

BCD range (0-9)

$4_{10} + 8_{10} = 12_{10}$

$0100_2 + 1000_2 = 1100_2 \rightarrow 12_{10}$

$0110_2 \rightarrow 6_{10}$

$(\underbrace{0001}\,\underbrace{0010})_{BCD}$

Binary Coded Decimal

$$
\begin{array}{r}
+\ 162 \\
769 \\
\hline
931
\end{array}
$$

$$
\begin{array}{ccc}
0001 & 0110 & 0010 \\
0111 & 0110 & 1001 \\
\hline
1000 & \underbrace{1100} & \underbrace{1011}
\end{array}
$$

doesn't exist in BCD

more than 9

to solve add 6_{10}

$$
\begin{array}{ccc}
 & 0110 & 0110 \\
\hline
\underbrace{1001}_{9} & \underbrace{0011}_{3} & \underbrace{0001}_{1}
\end{array}
$$

encoding → public UTF-8

encryption → special key

BOOLEAN LOGIC

$A+B$ → A or B

$A.B$ → A and B

$A', \bar{A}$ → NOT A

inputs

A	B	$A.B$	$A+B$	A'	B'
0	0	0	0	1	1
0	1	0	1	1	0
1	0	0	1	0	1
1	1	1	1	0	0

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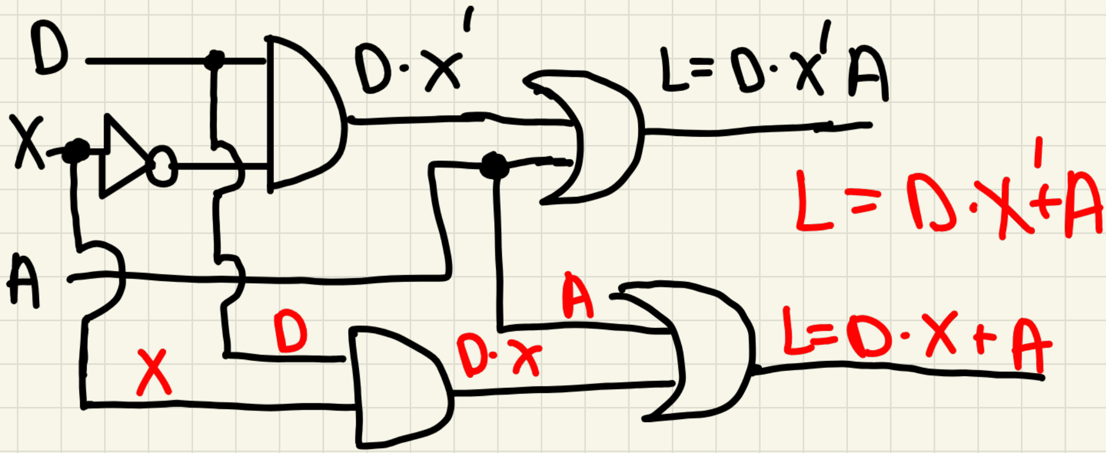
$$\underbrace{L}_{\text{output}} = \underbrace{D\cdot X' + A}_{\text{inputs}}$$

output

D	X	A	X'	$D\cdot X'$	$D\cdot X'+A$
0	0	0	1	0	0
0	0	1	1	0	1
0	1	0	0	0	0

0	1	1	0	0	1	
1	0	0	1	1	1	
1	0	1	1	1	1	
1	1	0	0	0	0	
1	1	1	0	0	1	



A	B	C	AB	A'C	BC		AB+A'C
0	0	0	0	0	0	0	0
0	0	1	0	1	0	1	1
0	1	0	0	0	0	0	0
0	1	1	1	0	1	1	1
1	0	0	0	0	0	0	0

1	0	1	0	0	0	0	0
1	1	0	1	0	0	1	1
1	1	1	1	0	1	1	1

$$F(A,B,C) = (A+B)(A+C)$$

$$AA + AC + AB + BC$$ Distributivity

$$A + AC + AB + BC$$ $A = AA$

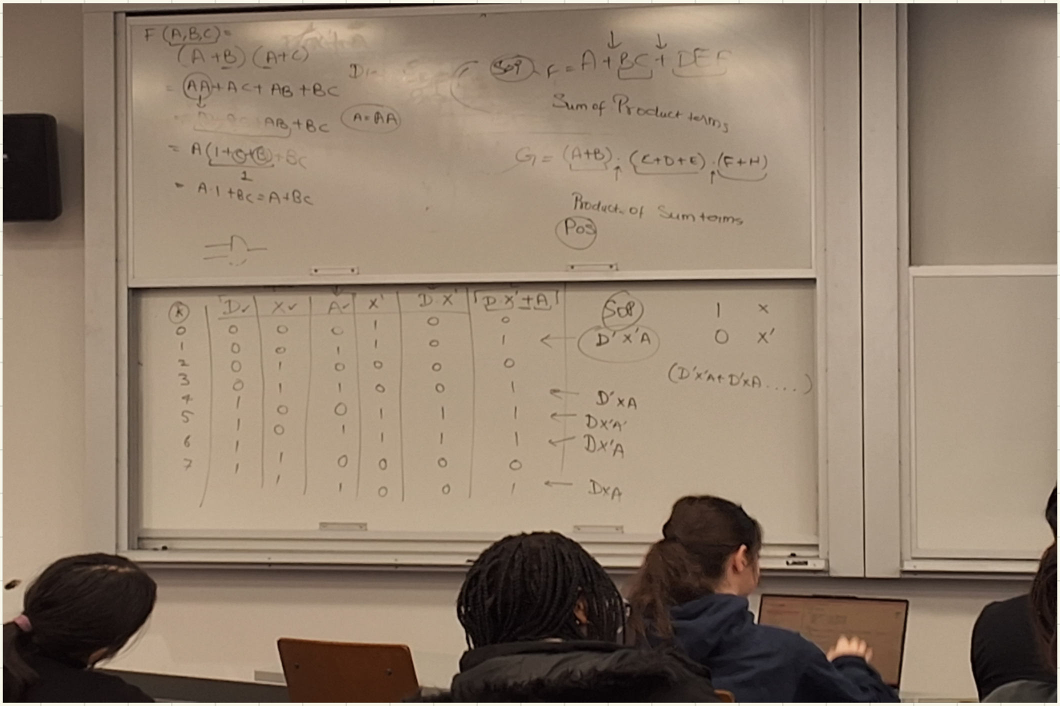
$$A(\underbrace{1 + C + B}_{1}) + BC$$

$$A \cdot 1 + BC = \boxed{A + BC}$$

Sum of Products SOP

$$F(A,B,C) = A'B'C + ABC + A'BC'$$

Product of Sum



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Q 1

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

$$\underbrace{y + xy'} + x'z$$

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

$$y + x + x'z$$

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

$$\boxed{y + x + z = x + y + z}$$

Q2

$$x'y' + x'y + xy = x'y$$

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

$$x' + xy$$

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

$$1 \cdot x' + y = \boxed{x'y}$$

Q3

$$x'y' + y'z + xz + xy + yz'$$ 13 operations

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

$$x'y' + xy'z + x'y'z + xz + xy + yz'$$

$$x'y'(1 + z) + xy'z + xz + xy + yz'$$

$$x'y' + xy'z + xz + xy + yz'$$

$$x'y' + xz(y' + 1) + xy + yz'$$

$$x'y' + xz + xy + yz'$$

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

$$x'y' + xz + xyz + xyz' + yz'$$

$$x'y' + xz + xyz + yz'(x+1)$$

$$x'y' + \underline{xz} + \underline{xyz} + yz'$$

$$x'y' + xz(1+z) + yz'$$

$$\boxed{x'y' + xz + yz'}$$ 8 operations

SOP

$$F(a,b,c) = a + bc + abc'$$

$$A(a,b,c) = \underbrace{abc}_{\text{Minterms}} + \underbrace{a'bc}_{\text{Minterms}} + \underbrace{abc'}_{\text{Minterms}}$$ Canonical

Minterms (product terms)

K	a	b	c	A	A
0	0	0	0	$a'b'c'$	0
1	0	0	1	$a'b'c$	0
2	0	1	0	$a'bc'$	0
3	0	1	1	$a'bc$	1
4	1	0	0	$ab'c'$	0
5	1	0	1	$ab'c$	0
6	1	1	0	abc'	1
7	1	1	1	abc	1

Minterms

SOP

$x = 1$

$x' = 0$

$$A(a,b,c) = \underset{\text{sum of products}}{\sum} m(3,6,7) \rightarrow \text{minterms}$$

POS (product of sum)

$$G(a,b,c) = \underbrace{(a+b+c')} \cdot \underbrace{(a'b'+c')} \cdot \underbrace{(a+b+c)}$$

Maxterms: $x=0$

POS $x'=1$

	a	b	c	P	
0	0	0	0	abc	1
1	0	0	1	abc'	1
2	0	1	0	$ab'c$	0
3	0	1	1	$ab'c'$	0
4	1	0	0	$a'bc$	0
5	1	0	1	$a'bc'$	0
6	1	1	0	$a'b'c$	0
7	1	1	1	$a'b'c'$	1

$$P(a,b,c) = \underbrace{\Pi M}_{\text{POS}} \underbrace{(0, 1, 7)}_{\text{maxterms}}$$

Always write Maxterms POS $x'=1$ $x=0$

Minterms SOP $x=1$ $x'=0$