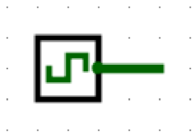
Discussion 5: SDS

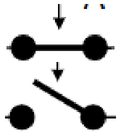
MENGYING WU

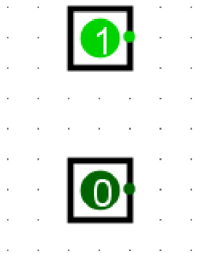
Synchronous Digital Systems

- Synchronous:
  - All operations coordinated by a central clock



- Digital:
  - Represent all values by 1 and 0
  - High voltage(V_{dd}) = True = On switch = 1
  - Low voltage (0V) = False = Off switch = 0

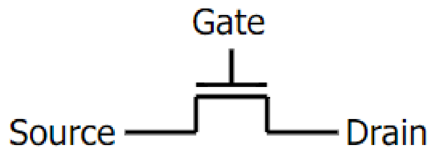




- Synchronous Digital Systems consist of two basic types of circuits:
  - Combinational Logic (CL) circuits
  - Sequential Logic (SL)

CMOS Transistor Networks

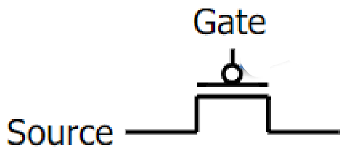
Negative



n-channel transitor

Off when voltage at Gate is low
On when voltage(Gate) > voltage (Threshold)
Can pass 0V when Gate is 1V

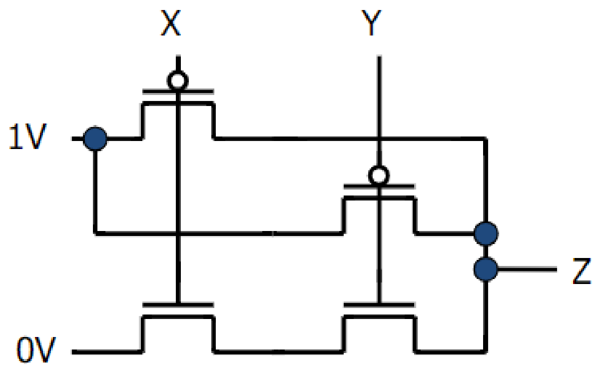
Positive



p-channel transistor

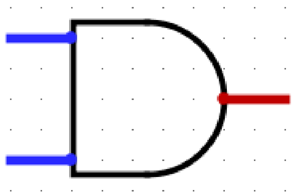
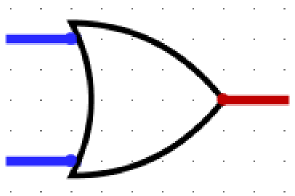
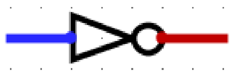
On when voltage at Gate is low
Off when voltage(Gate) > voltage (Threshold)
Can pass 1V when Gate is 0V

CMOS Networks



X	Y	Z
1	1	0
1	0	1
0	1	1
0	0	1

Combinational Logic

AND	$A \cdot B$	
OR	$A + B$	
NOT	$\overline{A}$	

Truth Table

- Same as Discrete Mathematics
- Single bit input

A	B	C
1	1	0
1	0	1
0	1	1
0	0	0

- Multiple bit input

A	B	C
$a_1 a_0$	$b_1 b_0$	$c_2 c_1 c_0$

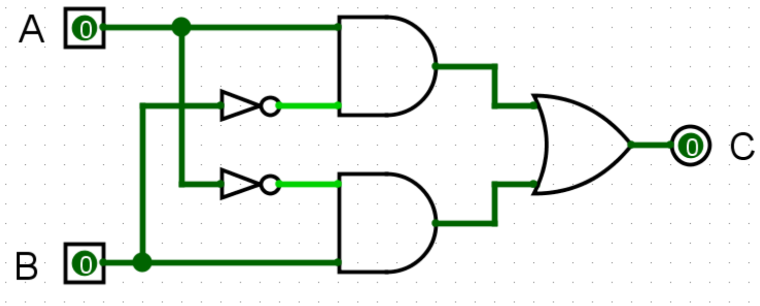
From Truth Table to logical expression

- Sum of Products form (AKA Principal Disjunctive Normal Form in Discrete Mathematics)
    - $C = A \cdot \bar{B} + \bar{A} \cdot B$
- This will help you simplify an unknown logic.
- Also you can use Product of Sums(AKA PCNF)
    - $C = (A + B) \cdot (\bar{A} + \bar{B})$
- Do not forget to use Laws of Boolean Algebra.

$X \overline{X} = 0$	$X + \overline{X} = 1$	Complementarity
$X\, 0 = 0$	$X + 1 = 1$	Laws of 0's and 1's
$X\, 1 = X$	$X + 0 = X$	Identities
$X X = X$	$X + X = X$	Idempotent Laws
$X Y = Y X$	$X + Y = Y + X$	Commutativity
$(X Y) Z = X (Y Z)$	$(X + Y) + Z = X + (Y + Z)$	Associativity
$X (Y + Z) = X Y + X Z$	$X + Y Z = (X + Y) (X + Z)$	Distribution
$X Y + X = X$	$(X + Y) X = X$	Uniting Theorem
$\overline{X} Y + X = X + Y$	$(\overline{X} + Y) X = X Y$	Uniting Theorem v. 2
$\overline{X Y} = \overline{X} + \overline{Y}$	$\overline{X + Y} = \overline{X}\, \overline{Y}$	DeMorgan's Law

Representations of Combinational Logic

Gate Diagram



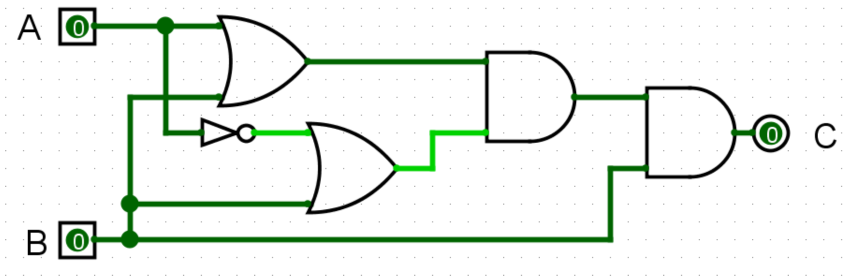
Boolean Expression

$$C = A \cdot \bar{B} + \bar{A} \cdot B$$

Truth Table

A	B	C
1	1	0
1	0	1
0	1	1
0	0	0

Example



$$
\begin{aligned}
C &= (A + B) \cdot (\bar{A} + B) \cdot B \\
&= (A \cdot \bar{A} + B \cdot \bar{A} + A \cdot B + B \cdot B) \cdot B \\
&= (B \cdot (\bar{A} + A) + B) \cdot B \\
&= (B + B) \cdot B \\
&= B \cdot B \\
&= B
\end{aligned}
$$