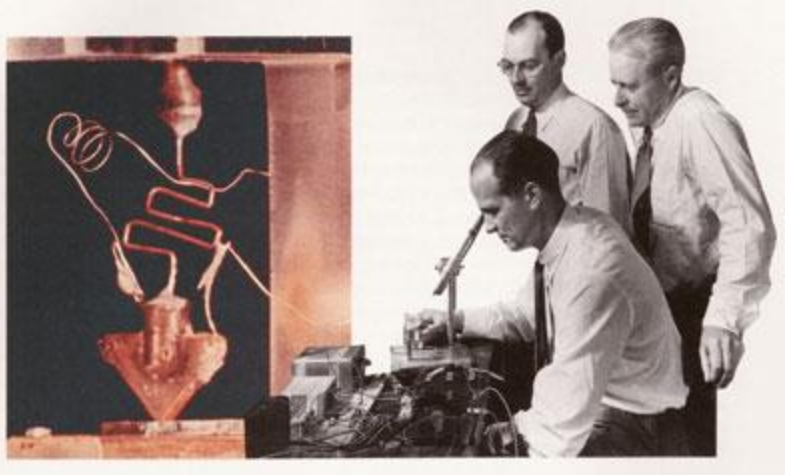
Digital Logic Design

Part 3

Binary digits

- Basic unit of information in digital communication: 0 or 1
- Represented internally as a high or low voltage
- Transistors : An on/off switch controlled by electricity

Transistors:



- The first transistor was invented in 1947 by William Shockley John Bardeen and Walter Brattain at Bell Laboratories.
- Most important electronics event of the 20th century: leading to IC (integrated circuit) and microprocessor technology serving as the basis of electronics

Image source: http://www.cedmagic.com/history/transistor-1947.html

Background on Transistors

- First Early Computer: Charles Babbage and Early form of Computers
  - Used Relays or Vacuum Tubes to represent states of matter
- Transistors : Cheap, Reliable and Small
  - Voltage applied to a control terminal (On or Off is generated)
- 1959: Robert Noyce: (Cofounded Fairchild Semiconductor and Intel) patented a method of interconnecting many transistors on a single chip.
  - At that time transistors cost was ~$10 ☺

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- 1959: Robert Noyce: (Cofounded Fairchild Semiconductor and Intel) patented a method of interconnecting many transistors on a single chip.
  - At that time transistors cost was ~$10 ☺
  - Today we can pack ~1billion MOS or MOSFET transistors onto $1cm^2$ silicon chip
  - Cost 10 microcents per transistor

MOSFETS : Metal-Oxide-semiconductor field effect transistors
Also Known As : MOS transistors

- Built from silicon (Si) : 4 valence electrons in outer shell
- Silicon forms strong crystal lattice:
- All electrons tied up in adjacent bonds →Therefore poor conductor
- However, (Si) becomes a better conductor when small amounts of impurities (called dopants) are added to this lattice structure
- N-Type: Small amounts of Arsenic(5 valence electrons) atoms added – leaving extra floating electrons that are not involved in bonding. Negatively charge particles
- P-Type: Small amounts of Boron(3 valence electrons) atoms added – leaving positively charged ions within the lattice: Results in Positively charged particles
- Silicon becomes a Semiconductor with the addition of dopants

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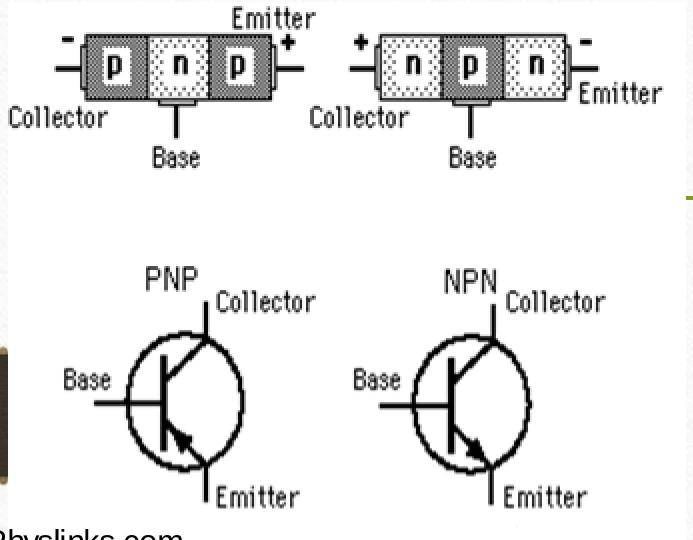
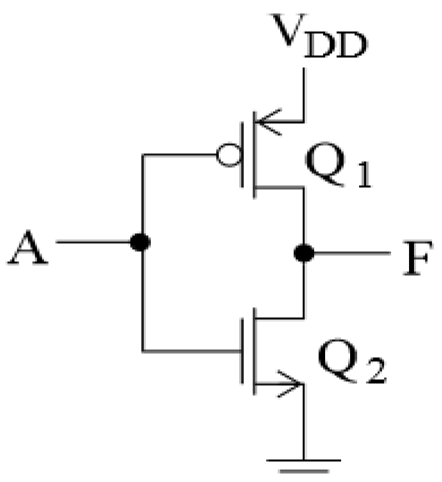


Physlinks.com

- MOS transistors :sandwich of layers of conducting and insulating materials
- nMOS (npn) and pMOS (pnp)
- Base Collector and Emitter Model: **Gate-Source-Drain**
- **Two types of Transistors have opposite behaviours**
- **That compliment each other: CMOS uses both nMOS and pMOS**

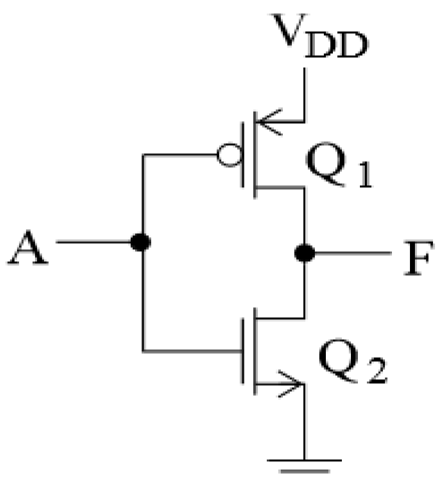
- Further Reading
- http://hyperphysics.phy-astr.gsu.edu/hbase/solids/dope.html#c4
- http://www.cs.mun.ca/~paul/transistors/node1.html
- **Go To Course Notes: Section 2: Transistors/ Examples on Board**



A	Q_1	Q_2	F
0	Low	High	1
1	High	Low	0

PMOS and NMOS together form CMOS:
Compliment MOS

WHY:
***We want both 0, 1 signals to be Strong readings**
Use properties of NMOS and CMOS together



A	Q_1	Q_2	F
0	Low	High	1
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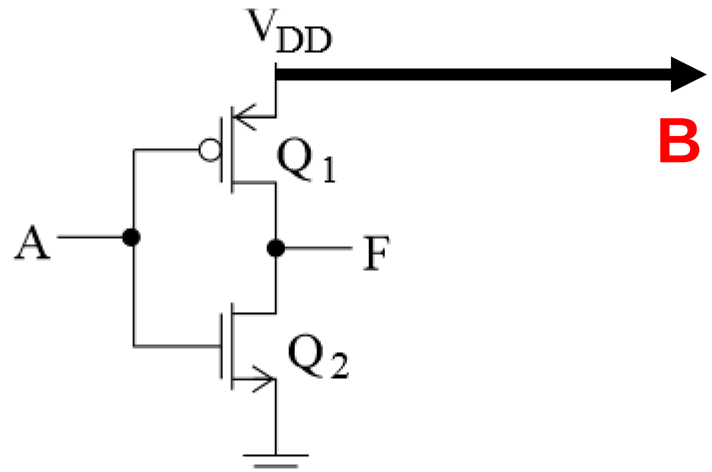
PMOS and NMOS together form CMOS:

A goes into the Gate at both Transistors

***Does a Signal pass or not pass**
***Are we connected to Ground**

➔That will determine F



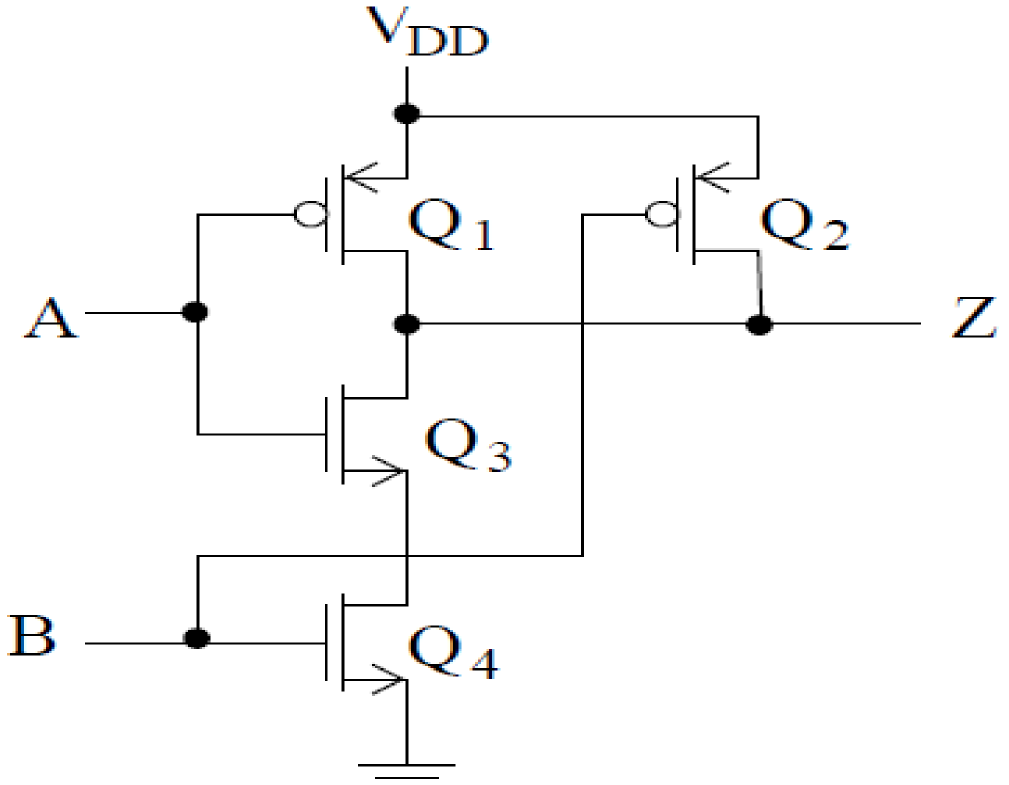
A	Q_1	Q_2	F
0	Low	High	1
1	High	Low	0

When A =0

What is the Output at B:

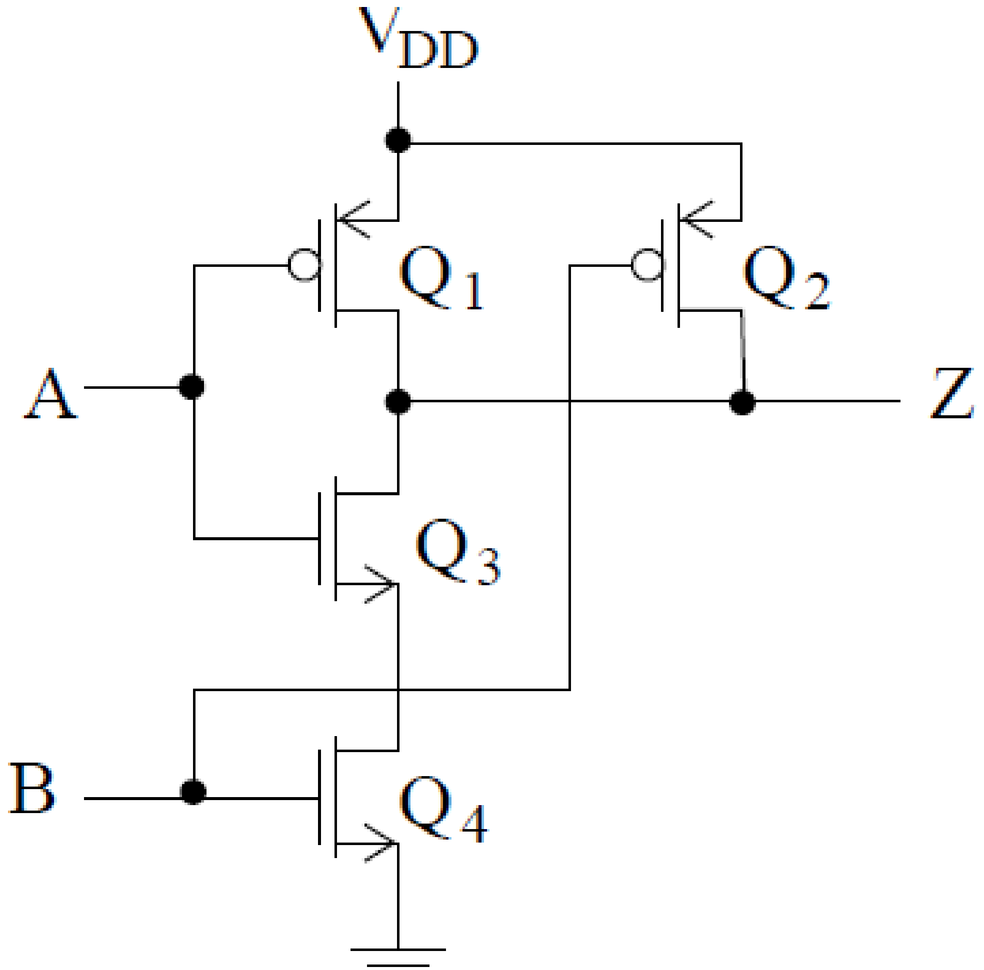
A)1
B)0
C)Neither
D)Vss
E)Ground

CMOS NAND



A	B	Q_1	Q_2	Q_3	Q_4	Z
0	0	Low	Low	High	High	1
0	1					
1	0					
1	1					

CMOS NAND



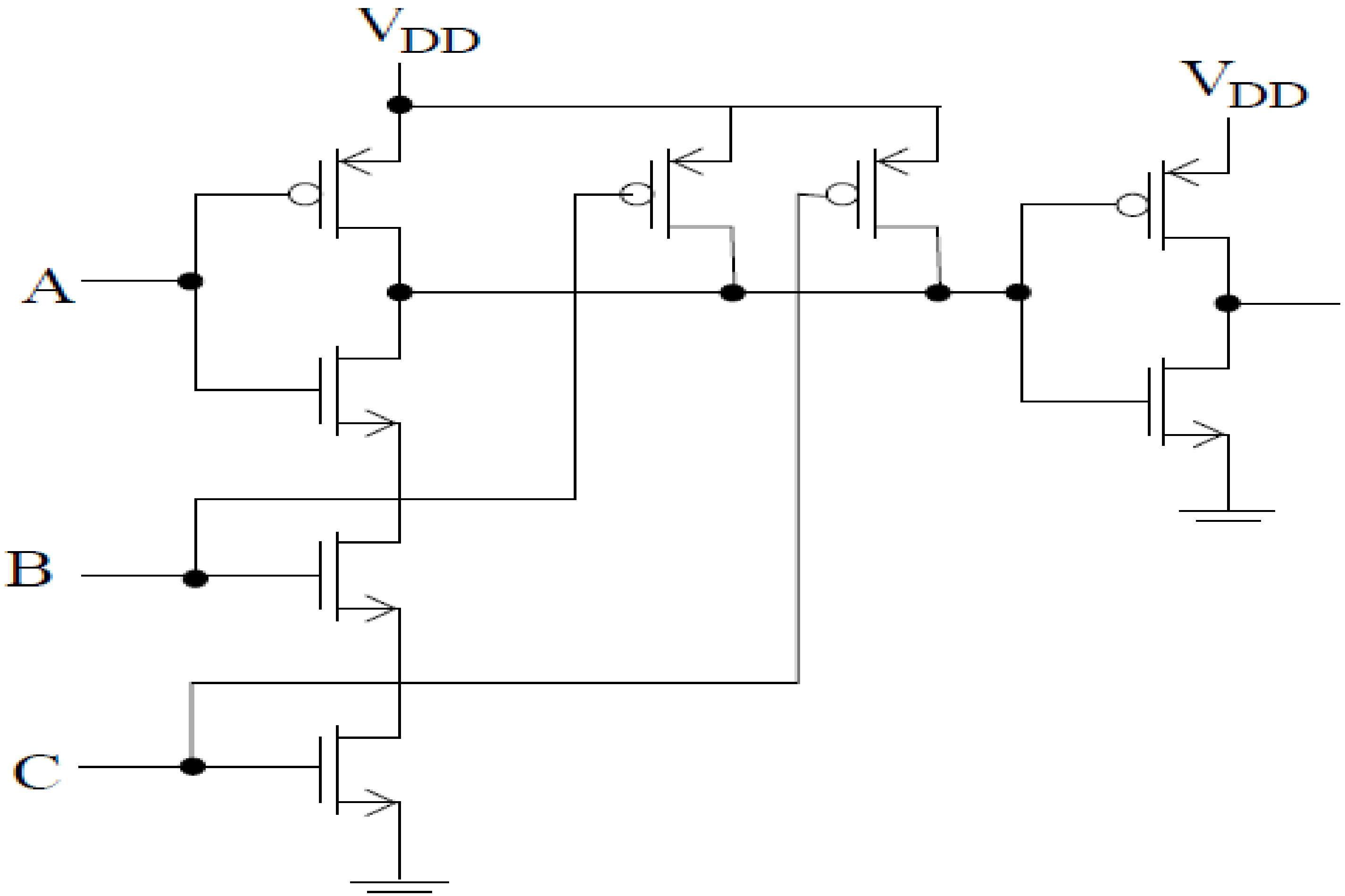
Scale up to 3 input NAND GATE

Add one more NMOS and one more PMOS per input

15-1-5

CMOS AND and OR

- To get AND and OR, add inverter at end
- Example: 3 Input AND



- Thus, NAND is preferred to AND in actual circuits

15-1-5

CMOS AND and OR

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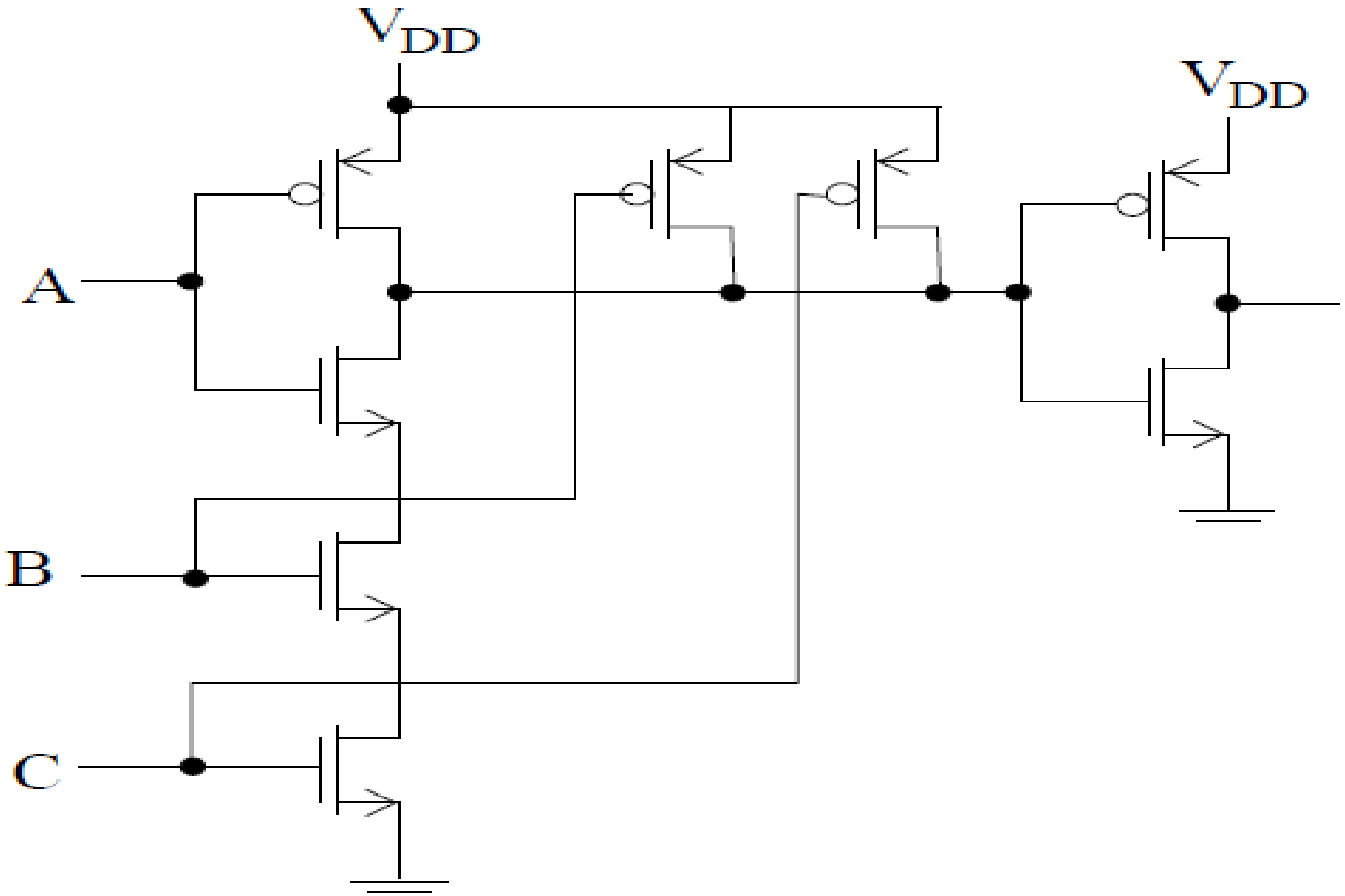
Designing our circuits Using NAND gates Is easier from Implementation Perspective.

Less Transistors In the hardware



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