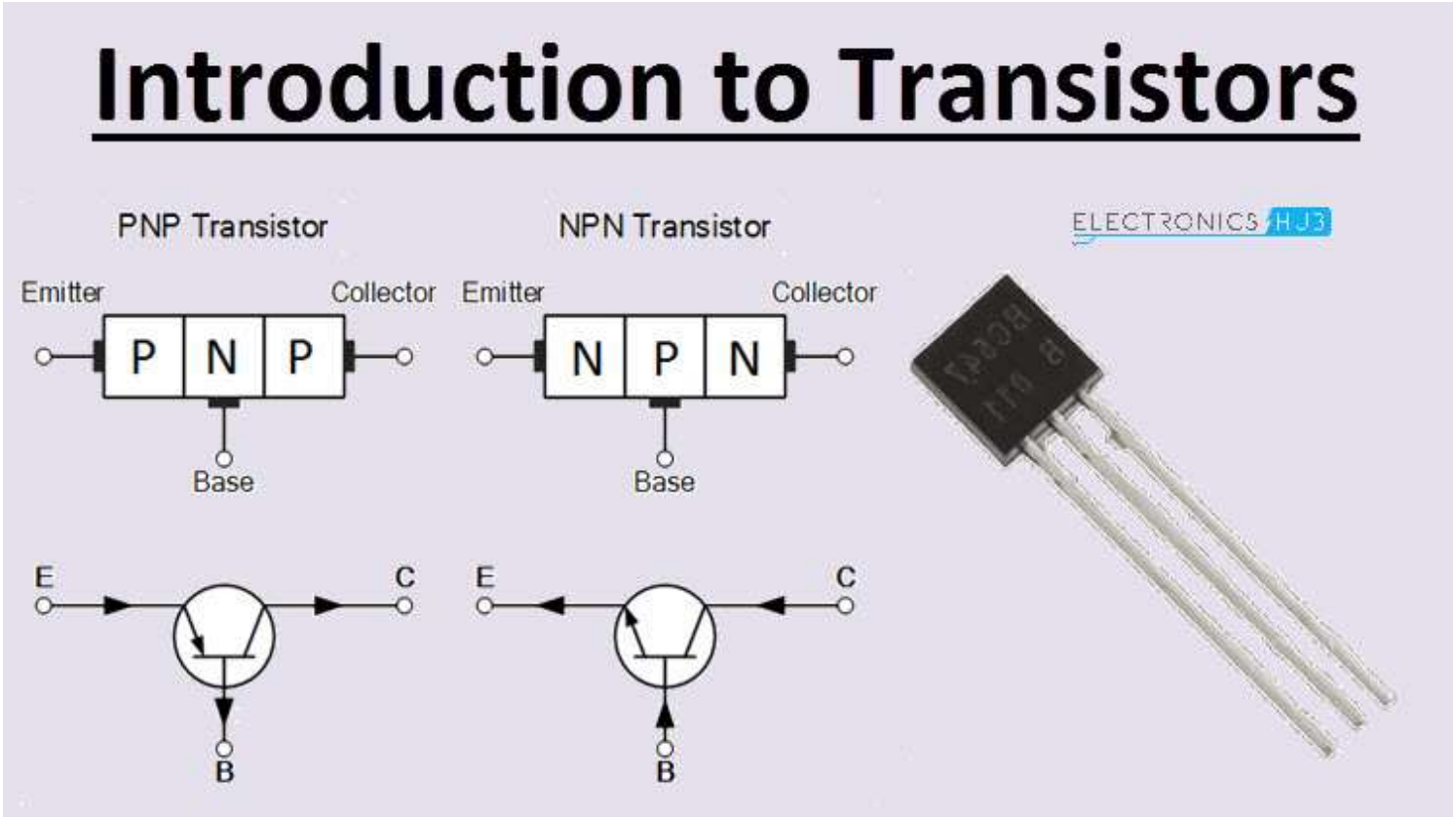
Introduction to VLSI

What is VLSI?

- **Very-large-scale integration (VLSI)** is the process of creating an integrated circuit (IC) by combining thousands of transistors into a single chip.
- **A transistor** is a semiconductor device used to amplify or switch electronic signals and electrical power. It is composed of semiconductor material usually with at least three terminals for connection to an external circuit.
- The process of Integrated Circuits (IC) started its era of VLSI in 1970's when thousands of transistors were integrated into one single chip.
- Nowadays we are able to integrate more than a billion transistors on a single chip.

Transistor


Introduction to Transistors
PNP Transistor
NPN Transistor
ELECTRONICS HUB
Emitter
Collector
P
N
P
Base
E
C
B
Emitter
Collector
N
P
N
Base
E
C
B

What is VLSI?

- An electronic circuit might consist of a CPU, ROM, RAM and other glue logic. VLSI lets IC designers add all of these into one.
- Now multiple cores are available on a single chip and advantage of that the computer can perform several function parallelly and can process the several threads of a single function parallelly.

Core
Thread

VLSI (Continue…)

- However, the term “VLSI” is still being used, though there was some effort to coin a new term ULSI (Ultra-Large Scale Integration) for fine distinctions many years ago.
- The microprocessor is a VLSI device.
- VLSI circuits are used everywhere, real applications include
  - microprocessors in a personal computer or workstation,
  - chips in a graphic card,
  - digital camera or camcorder,
  - chips in a cell phone or a portable computing device,
  - and embedded processors in an automobile

VLSI (Continue…)

- Multiplexers, Encoders, flip-flops. Many such functionalities are combined in ASICs(Application Specific Integrated Circuits).
- VLSI can be implemented using a language called VLSI HDL(Hardware Description Language) which describes the layout, design and Microchips are becoming smaller and smaller.

ASIC - Application Specific IC

Integrated Circuits

- Integrated circuit or IC or microchip or chip is a microscopic electronic circuit array formed by the fabrication of various electrical and electronic components (resistors, capacitors, transistors, and so on) on a semiconductor material (silicon) wafer, which can perform operations similar to the large discrete electronic circuits made of discrete electronic components.

Classification of IC according to size of integration

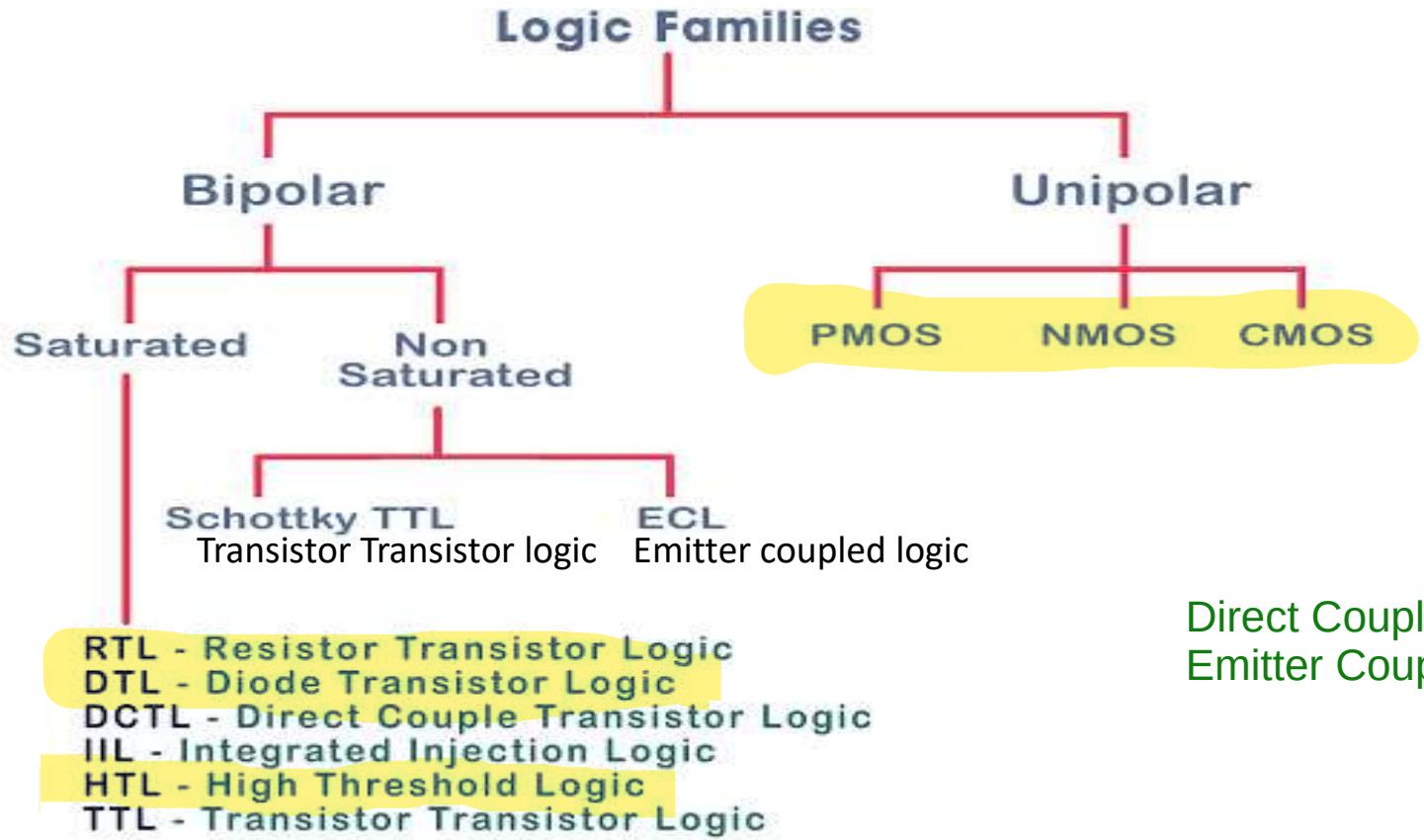
- Small scale integration (SSI) circuits such as the 7404 inverter have fewer than 10 gates with a conversion of roughly half a dozen transistors per gate
- Medium scale integration (MSI) circuit such as 74161 counter have up to 1000 gates.
- Large scale integration (LSI) circuit such as simple 8-bit microprocessors have up to 10000 gates.
- VLSI such as 512 Mbits dynamic RAM contains more than half a billion transistors.

Classification of IC according to size of integration

Generations

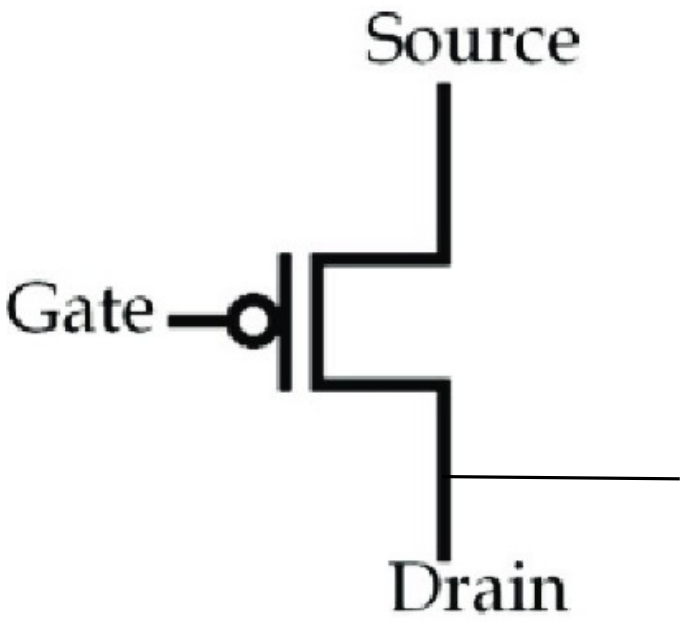
Name	Signification	Transistors number
SSI	small-scale **integration**	1 to 10
MSI	medium-scale **integration**	10 to 500
LSI	large-scale **integration**	500 to 20 000
VLSI	very large-scale **integration**	20 000 to 1 000 000

Logics Family

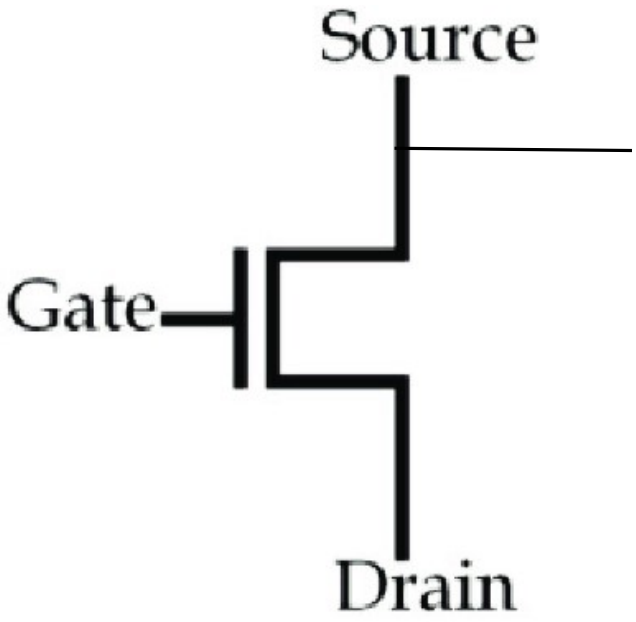


Direct Couple
Emitter Coupled

Unipolar Logic



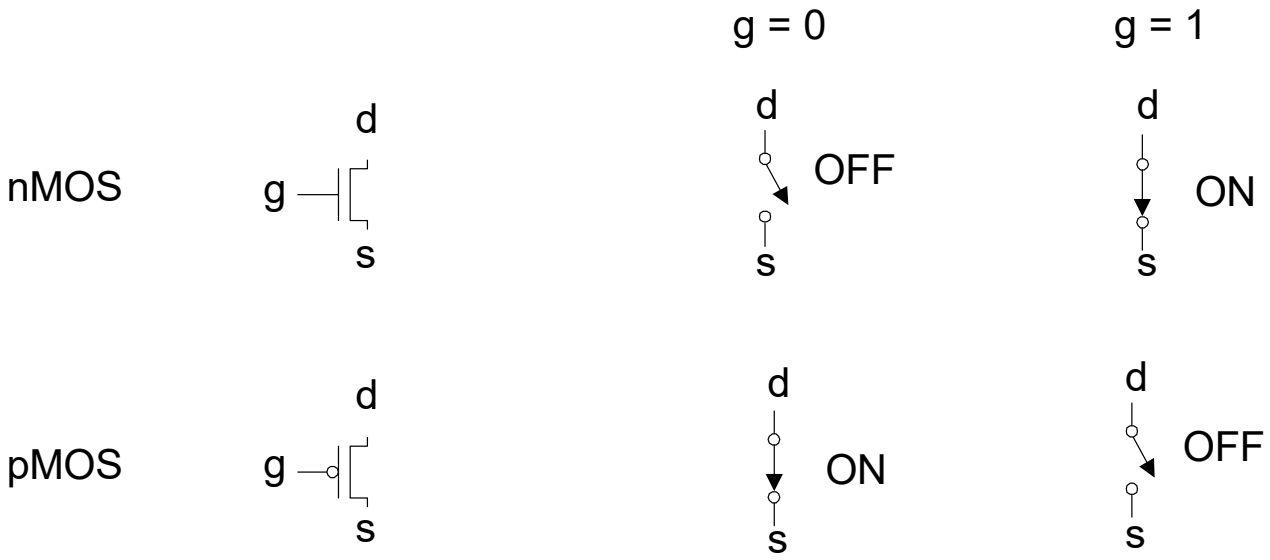
(a)



(b)

g - GATE

PMOS and NMOS Logics

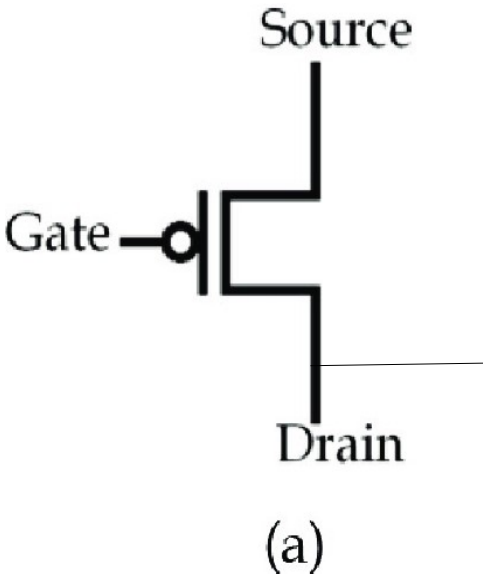


PMOS and NMOS Logics

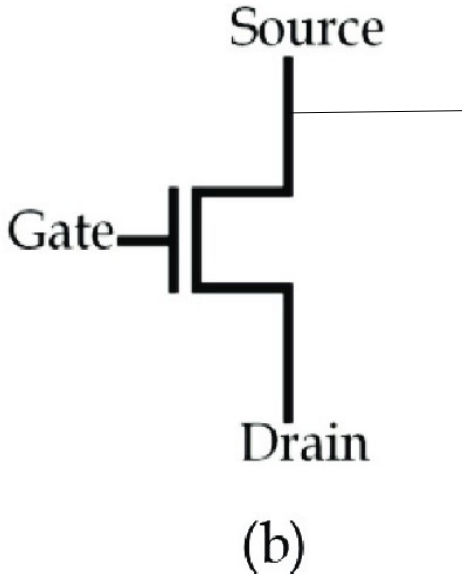
Voltage	PMOS	NMOS
0V (0)	ON	OFF
5V (1)	OFF	ON

PMOS (A)	Output (Y)
0	1
1	0

NMOS (A)	Output (Y)
0	0
1	1



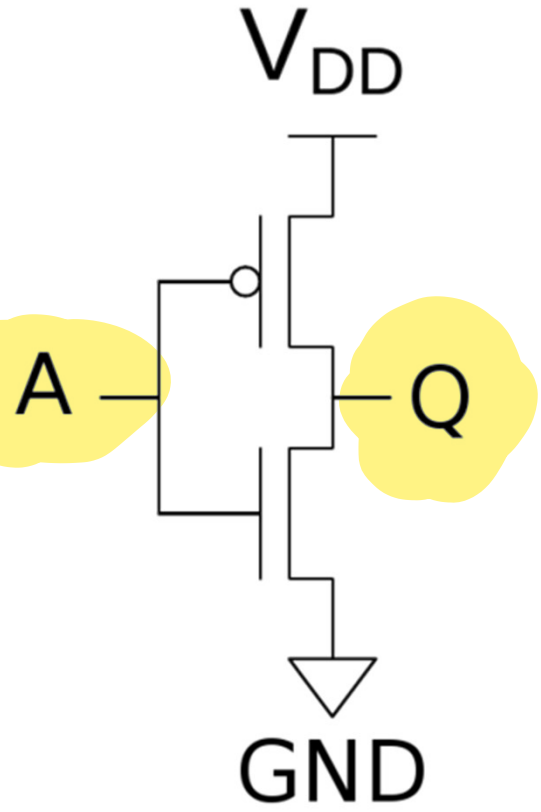
(a)



(b)

CMOS Inverter

Complementary metal–oxide–semiconductor (CMOS), also known as complementary-symmetry metal–oxide–semiconductor, is a type of metal–oxide–semiconductor field-effect transistor fabrication process that uses complementary and symmetrical pairs of p-type and n-type MOSFETs for logic functions.

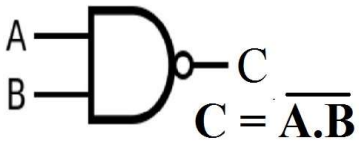


A (Input)	Q1	Q2	Q (Output)
0	ON	OFF	1
1	OFF	ON	0

Complementary Metal-Oxide Semiconductor

CMOS NAND gate

NAND GATE



Truth Table

INPUT		OUTPUT
A	B	A NAND B
0	0	1
0	1	1
1	0	1
1	1	0

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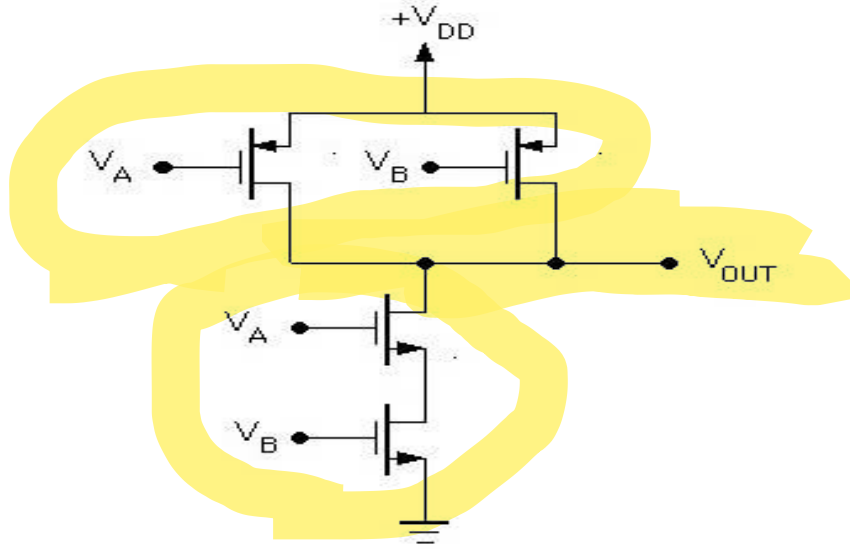
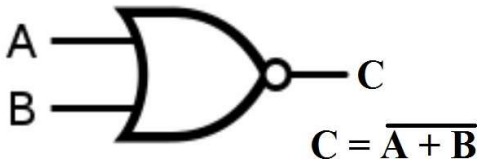


Va	Vb	Q1	Q2	Q3	Q4	Vout
0	0	ON	ON	OFF	OFF	1
0	1	ON	OFF	OFF	ON	1
1	0	OFF	ON	ON	OFF	1
1	1	OFF	OFF	ON	ON	0

Truth Table

CMOS NOR gate?

NOR GATE



TRUTH TABLE

INPUT		OUTPUT
A	B	A NOR B
0	0	1
0	1	0
1	0	0
1	1	0

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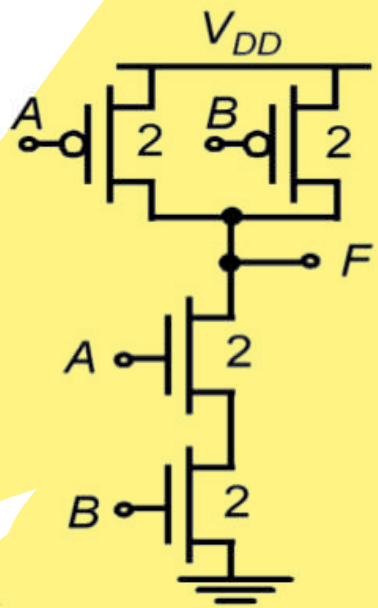
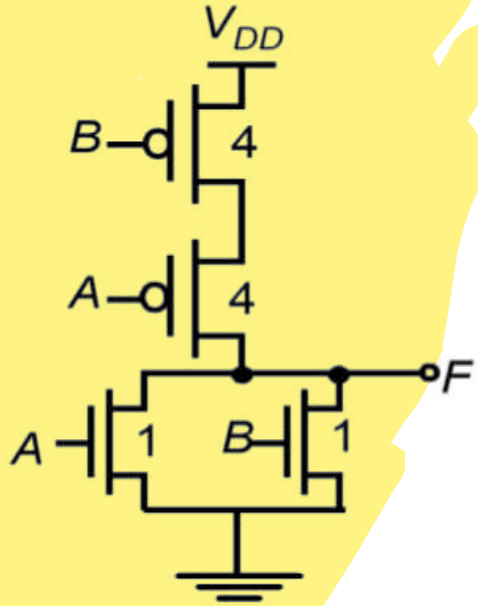
A	B	NMOS-V1	NMOS-V2	PMOS-V1	PMOS-V2	Vout
0	0	off	off	on	on	1
0	1	off	on	on	off	0
1	0	on	off	off	on	0
1	1	on	on	off	off	0

CMOS-2 Input NAND & NOR GATE





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Stick Diagram

- **Stick diagrams** are a means of capturing topography and layer information using simple **diagrams**.
- **Stick diagrams** convey layer information through color codes (or monochrome encoding).

CMOS Inverter