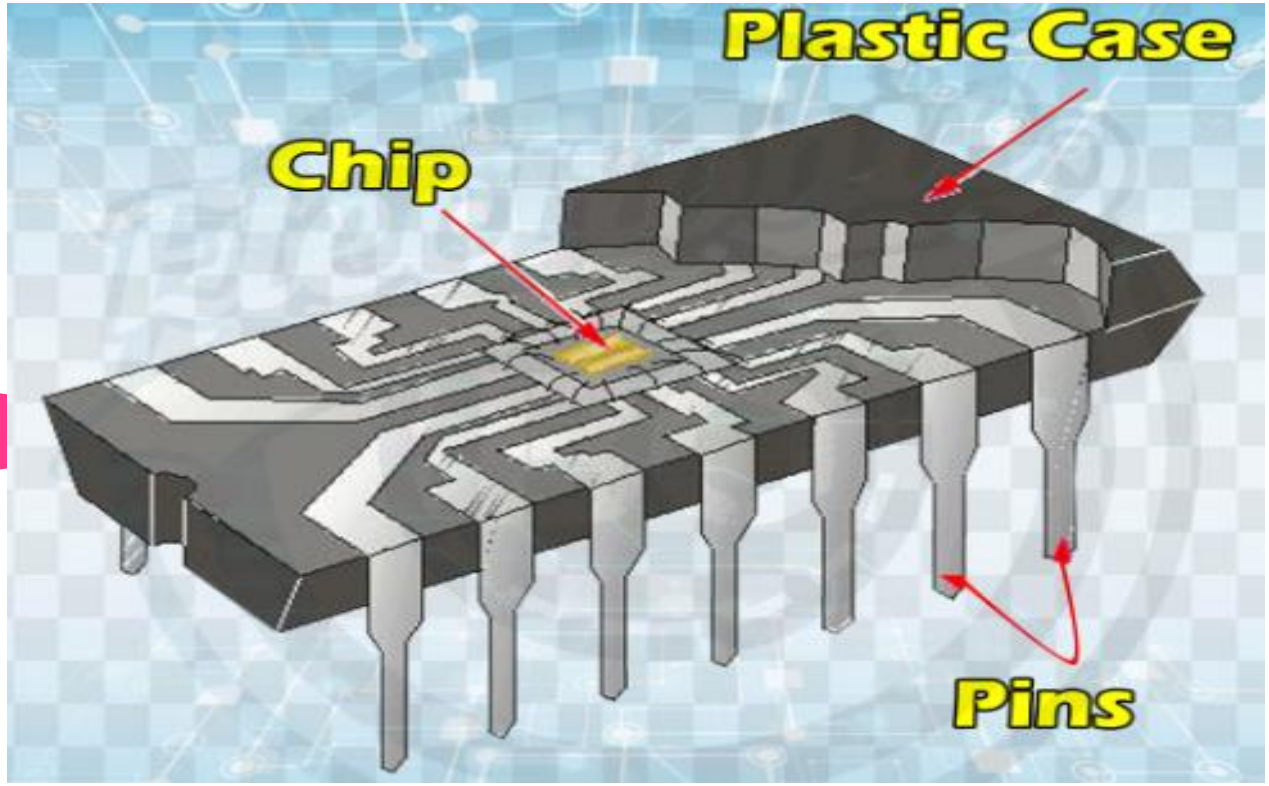
Unit-5:
Logic Families

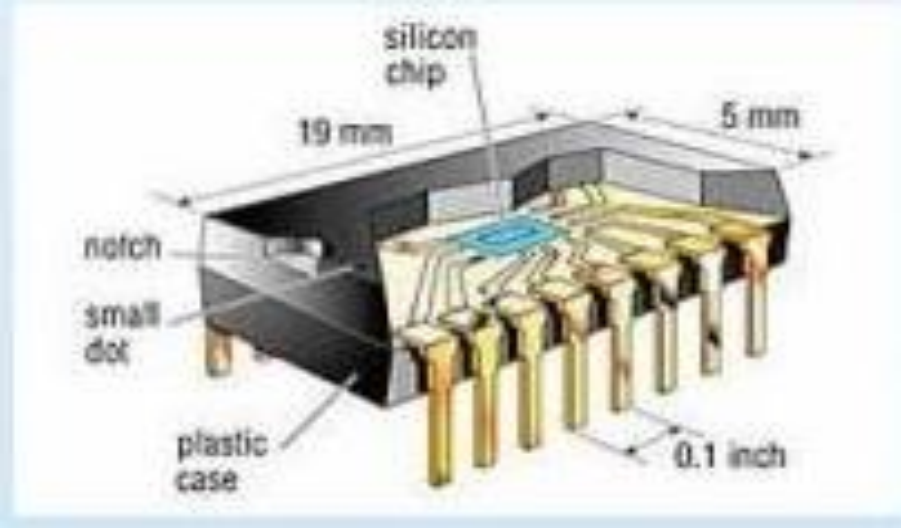


1. INTRODUCTION

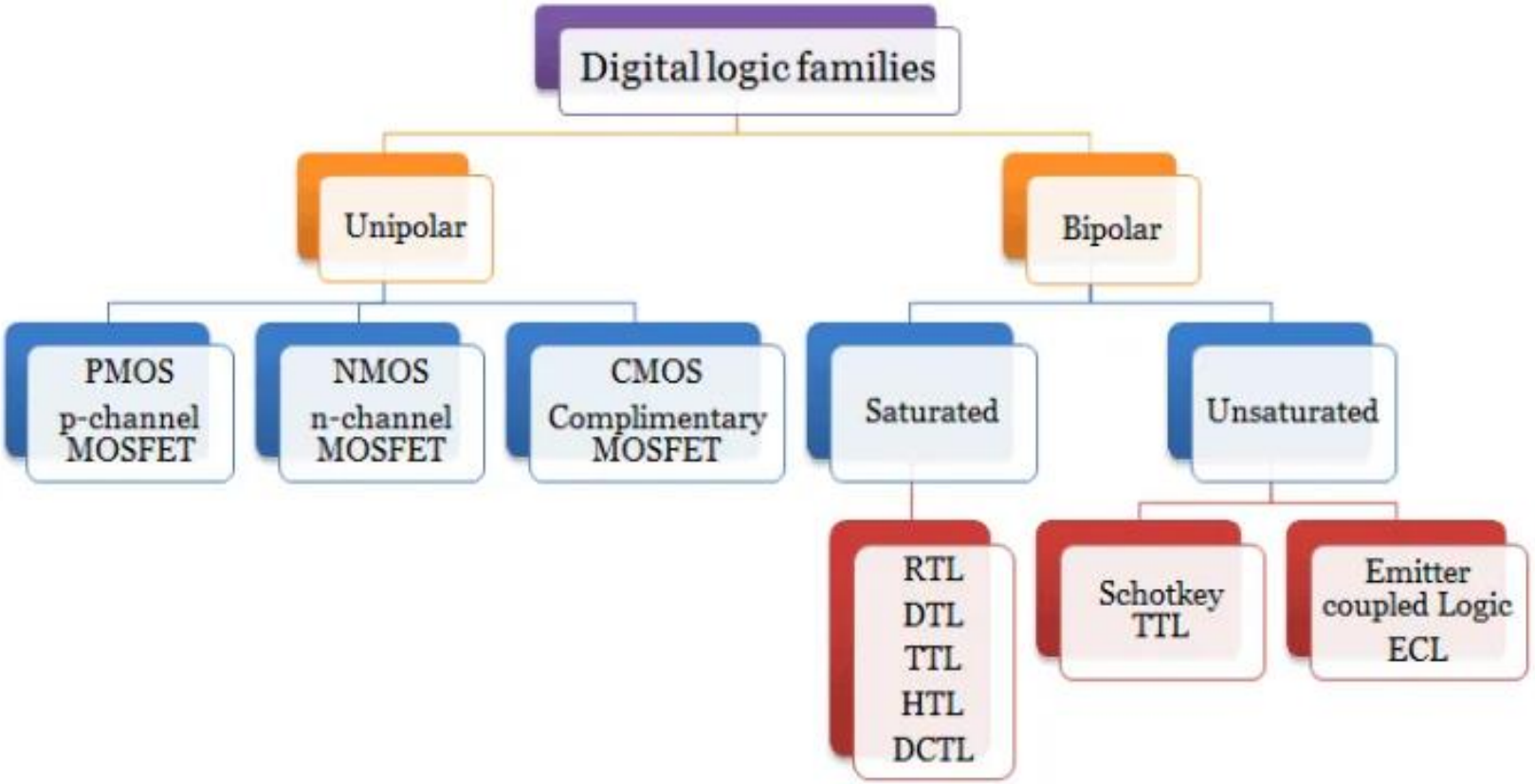
- Logic gates are available in the form of Integrated circuit(IC's)

- As per the level of integration, IC's can accommodate more number of logic gates and digital functions.

- These forms are referred as logic family.



2.Classification of Logic Families



3. IMPORTANT POINTS

- The digital familiy is categorized by two types

  (i) Bipolar and (ii) Unipolar

- In Saturated Bipolar logic families, Transistor in the IC driven in to saturation.

  In Non Saturated Bipolar logic families, Transistor in the IC not driven in to saturation.

- In PMOS & NMOS Unipolar logic family only P & N channel MOSFETs are used.

  CMOS Unipolar logic family both P & N- channel MOSFETs are used.

Logic Families

OBSOLETE ONES:

1. **Diode Logic.**
2. **Diode Transistor Logic (DTL).**
3. **Resistor Transistor Logic (RTL).**

CURRENT ONES:

1. **TTL (Transistor Transistor Logic)**
2. **ECL (Emitter Coupled Logic)**
3. **CMOS (Complementary Metal Oxide Semiconductor)**

4. LEVEL OF INTEGRATION

- Number of gates fabricated in single IC
- There are 4 generation
  - Small Scale Integration (SSI) = 3-30 gates in 1 Chip (around 10 -100 transistor)
  - Medium Scale Integration (MSI) = 30 to 300 gates
  - Large Scale Integration(LSI)= 300 to 3000 gates
  - Very Large Scale Integration(VLSI)= more than 3000 gates (20000- 50000 transistor)
  - Ultra Large Scale Integration- 50,000 to billions of transistors are fabricated on a single chip

SSI- These ICs are used to make flip-flops and logic gate ICs.

MSI- Used to make multiplexers, decoders, counters, and registers.

LSI- Used to make RAM, ROM, and microprocessors.

VLSI- Used to design digital signal processors (DSP), RISC processors, 16-bit and 32-bit microprocessors and microcontrollers.

ULSI- Mainly used for designing 64-bit and higher microprocessors and controllers.

Characteristics of digital logic family

Propagation delay

- It is an important characteristic of the digital logic family.
- It is the time interval between the application of the input pulse and the occurrence of the output.
- If the propagation delay is less, then the ***speed*** at which the IC operates will be faster.

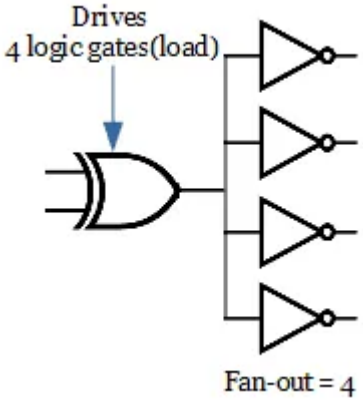
Fan in and Fan out

Fan-in refers to the number of inputs in a digital logic gate family.

The EX-OR gate has three inputs. So fan-in for the given EX-OR gate is 3.

Fan-out refers to the number of inputs that is driven by the output of another logic gates.

For example, the following circuit has an EX-OR gate, which drives 4 NOT gates. So fan-out of EX-OR gate is 4.



Power dissipation

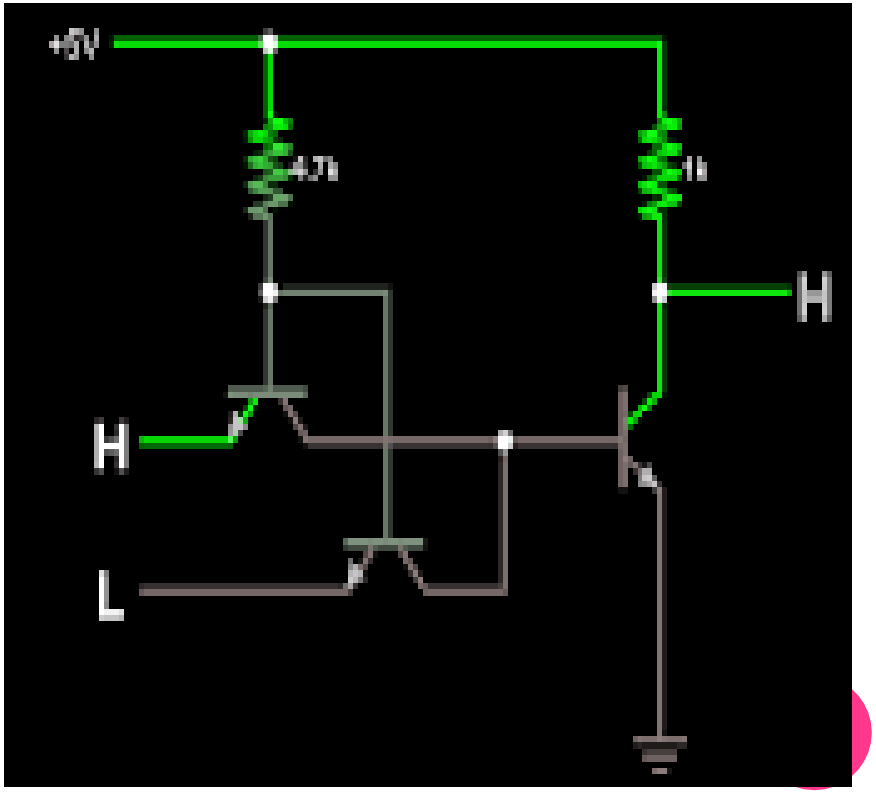
- It is the amount of power that digital circuit dissipates.
- The power dissipated is determined by the average current, that is drawn from the supply voltage.

The average current is the average value of the current at LOW gate output (logic ‘o’) and the current at HIGH gate output(logic ‘1’).

TRANSISTOR –TRANSISTOR LOGIC (TTL) CIRCUIT

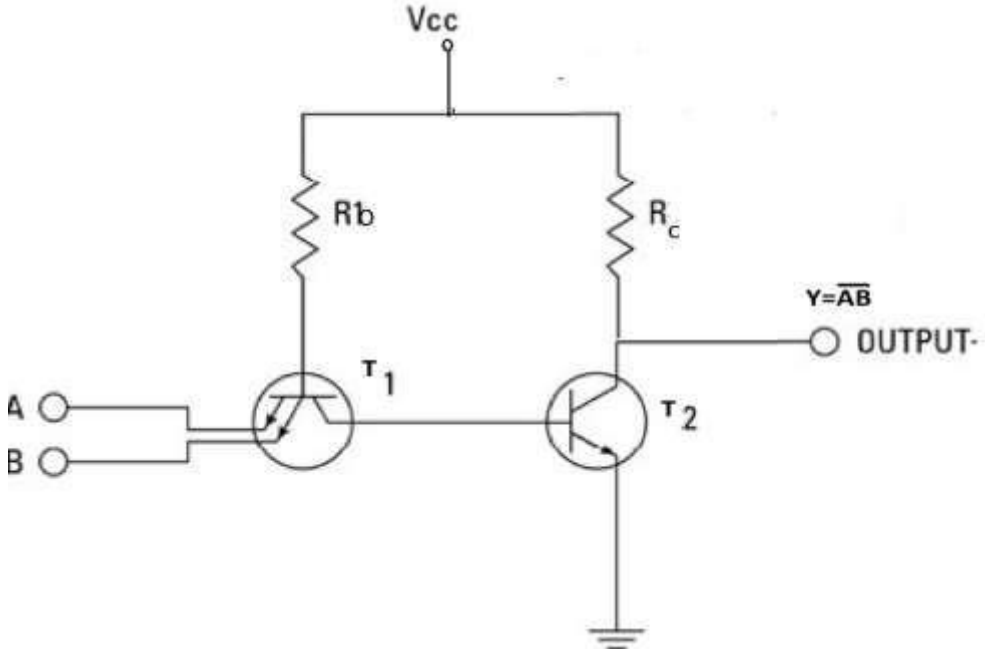
- TTL is an integrated circuit that performs a logic function to provide a switching function by using bipolar transistors.

- High Speed(tp= 10 ns)
- Low power dissipation
- Fan – In from 12 -14
- Fan out equals to 10 or more



TTL NAND GATEs

- The multi emitter transistor T1 is used to drive the output of T2
- Inputs are given in Emitter of T1& output is taken from Collector of T2.



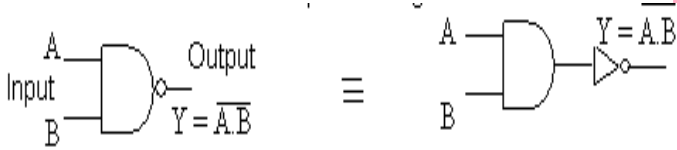


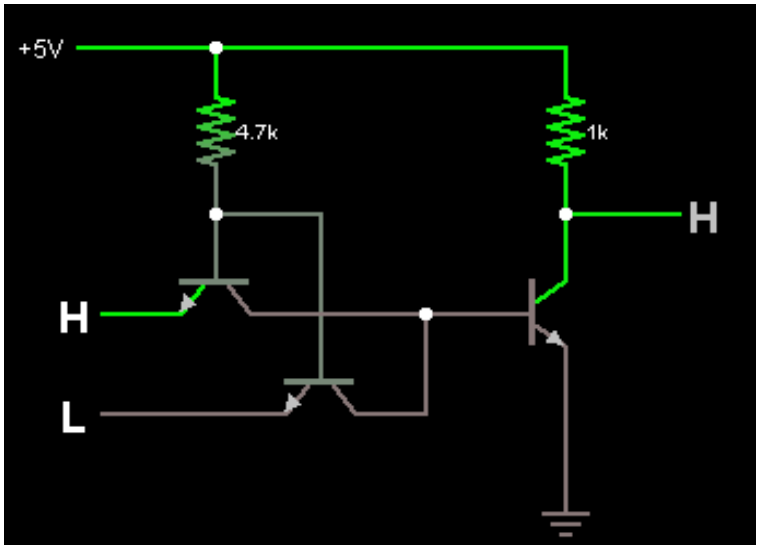
Fig.3.6:Graphic symbol of NAND Gate

INPUTS		OUTPUT
A	B	Y=$\overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0

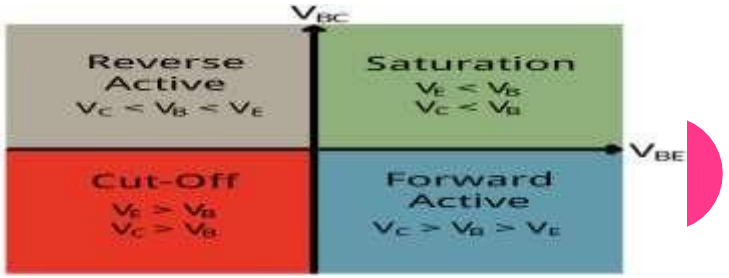
Table 3.4 : Truth Table for NAND Gate

OPERATION

- If one of the input is ‘0’(LOW), the corresponding **Emitter** juction is **forward biased** (VE< VB) **So T1 is in Saturation region (ON)** & collector also biased to conduct but the voltage is low(0.3V) , **t**his forces T2 OFF. Because the collector voltage of T1 is Base voltage of T2. So the output taken from the collector of T2 is **HIGH** ie “1”
- If both the input is HIGH then **both emitter reverse bias** so T1 is in **CutOff (OFF)** region , this increases collector voltage of T1 that Pulls T2 to Saturation (ON) thus the output is LOW(0)



EMITTER INPUT	T1	T2	COLLECTOR OUTPUT
0,0 0,1 1,0	SATURATION ON	OFF	HIGH= 1 HIGH= 1 HIGH= 1
1,1	CUT OFF OFF	SATURATION ON	LOW = 0



MOS/ CMOS CIRCUIT

- Metal Oxide Semiconductor(MOS) field effect transistor. There are 3 types
  - P MOS- P- Channel MOSFET – slowest
  - N MOS – N Channel MOSFET – Microprocessor & Memories
  - C MOS (Complementary MOS) – both N& P Channel
    - ADVANTAGES:
      - LOW POWER DISSIPATION
      - LOW NOISE
      - HIGH FAN OUT
      - HIGH SWITCHING SPEED
      - BETTER COMPATIBILITY

TTL vs CMOS

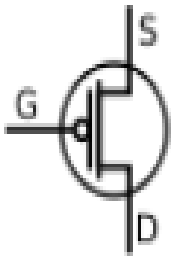
- TTL
  - faster (some versions)
  - strong drive capability
  - rugged
- CMOS
  - lower power consumption
  - simpler to make
  - greater packing density
  - better noise immunity

MOS as a Switch

PMOS

ON➔ Gate input Low

OFF➔ Gate input High

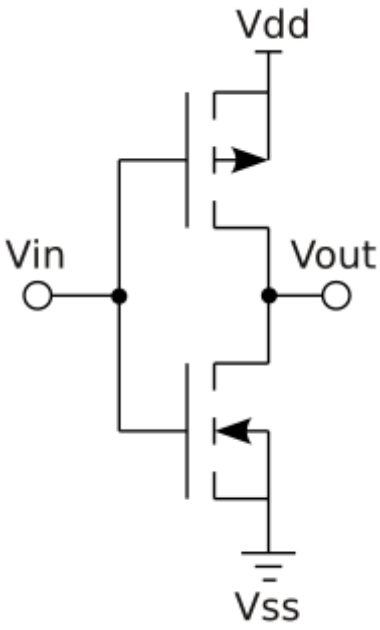


NMOS

OFF➔ Gate input Low

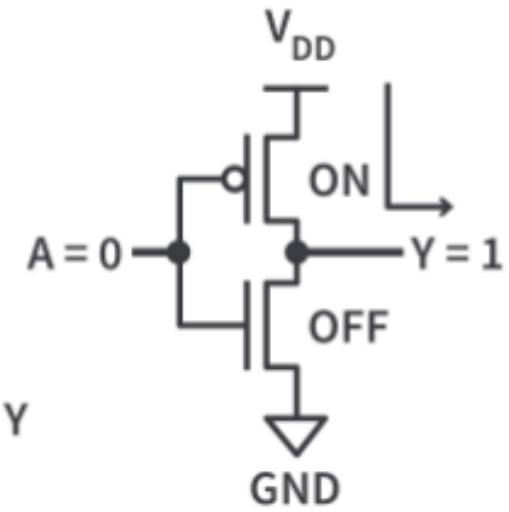
ON➔ Gate input High

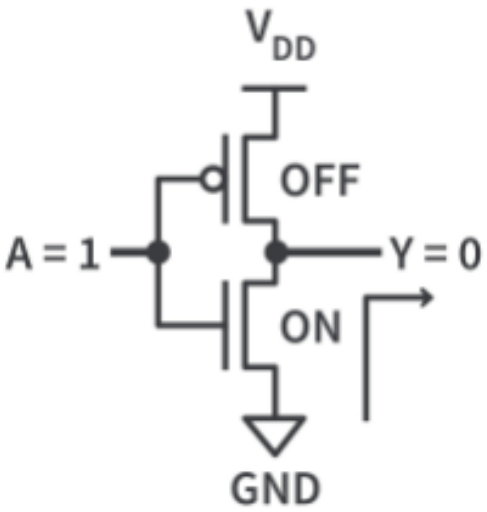
CMOS



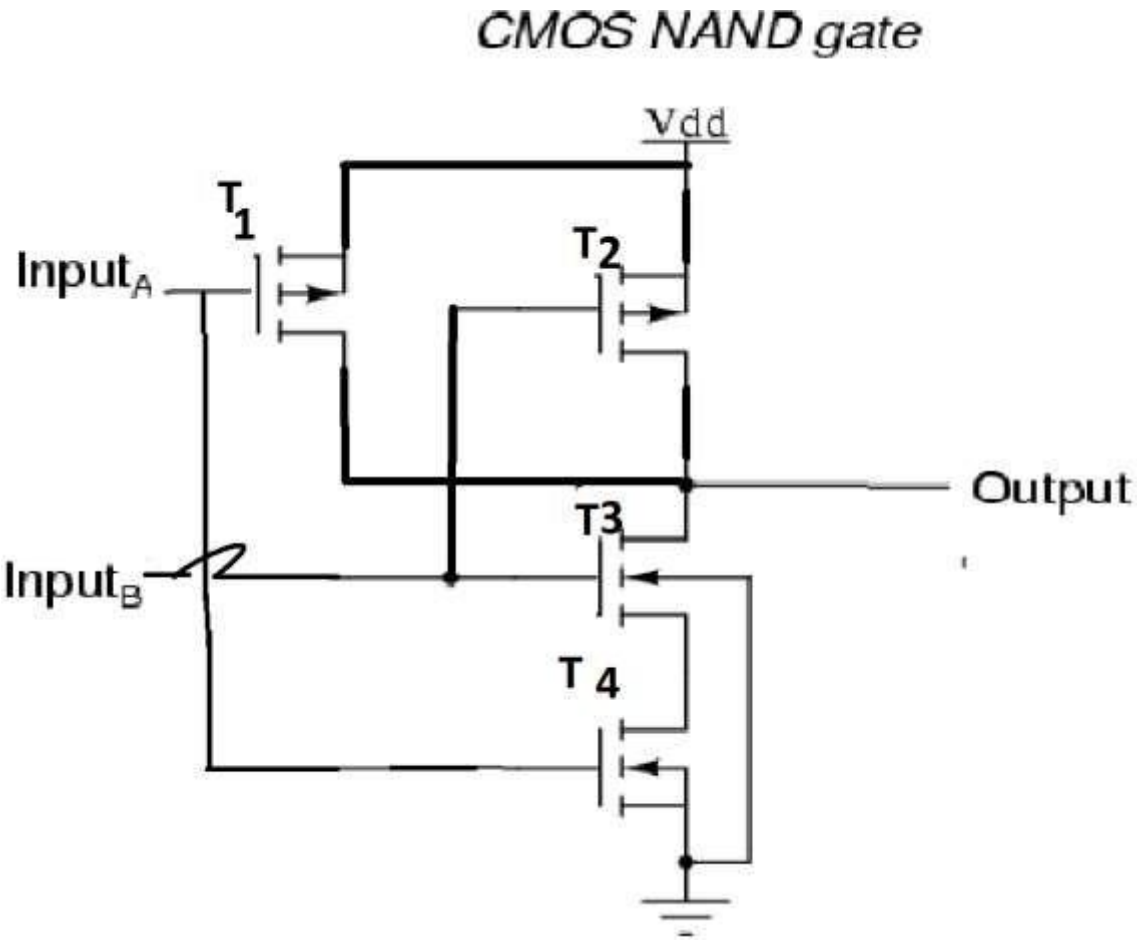
CMOS Inverter

A	Y
0	1
1	0



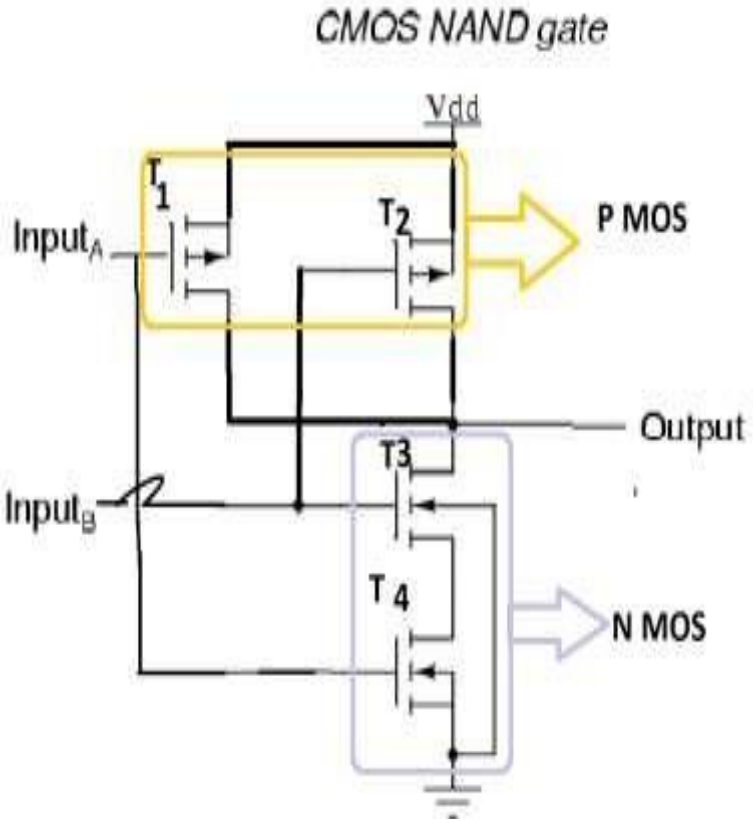


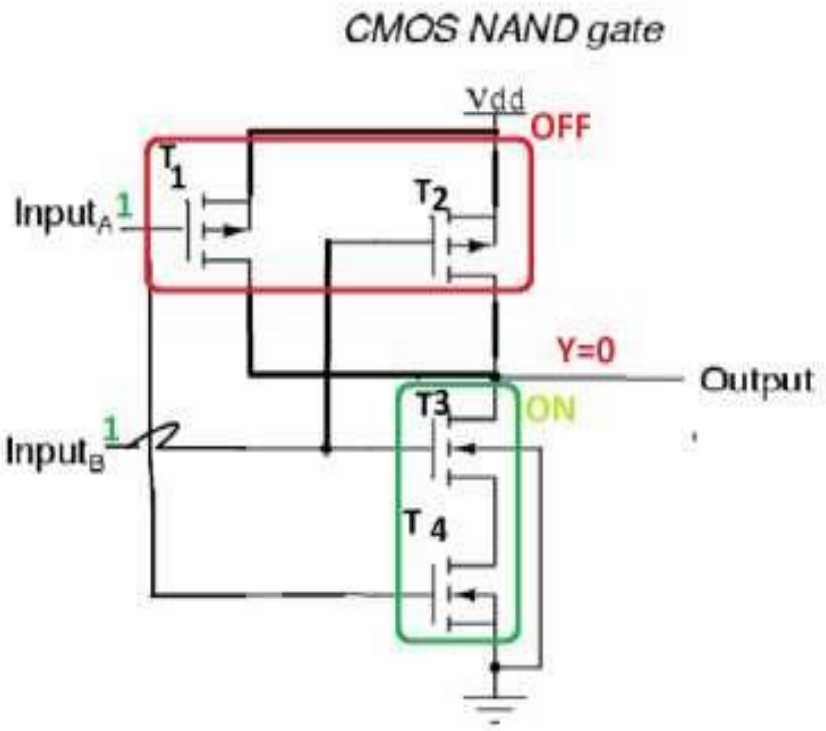
CMOS NAND GATE



CMOS NAND GATE OPERATION

- T1 & T2 are p-channel MOSFET
- T3 & T4 are n-channel MOSFET
- If inputs are high ‘1’ then p-channel MOSFET (T1 & T2 – OFF), n-channel MOSFET (T3& T4 – ON), so the output is low.

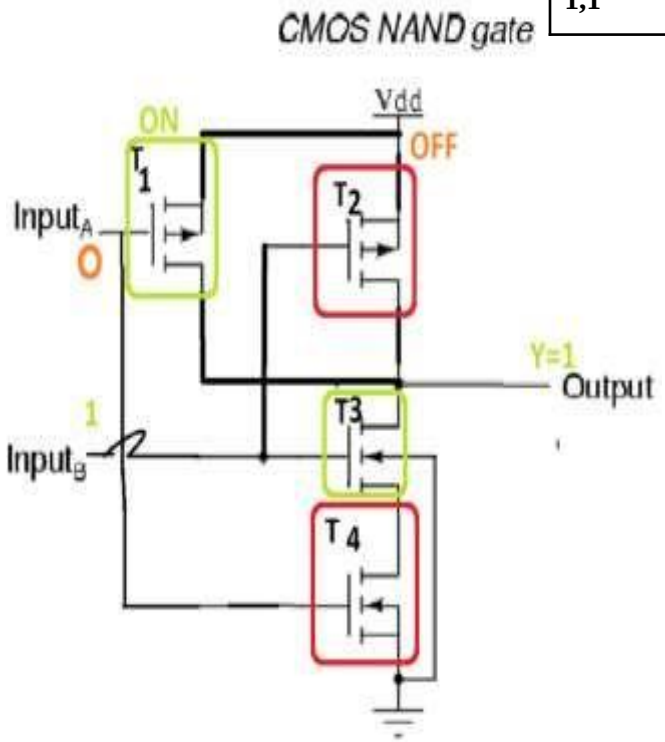


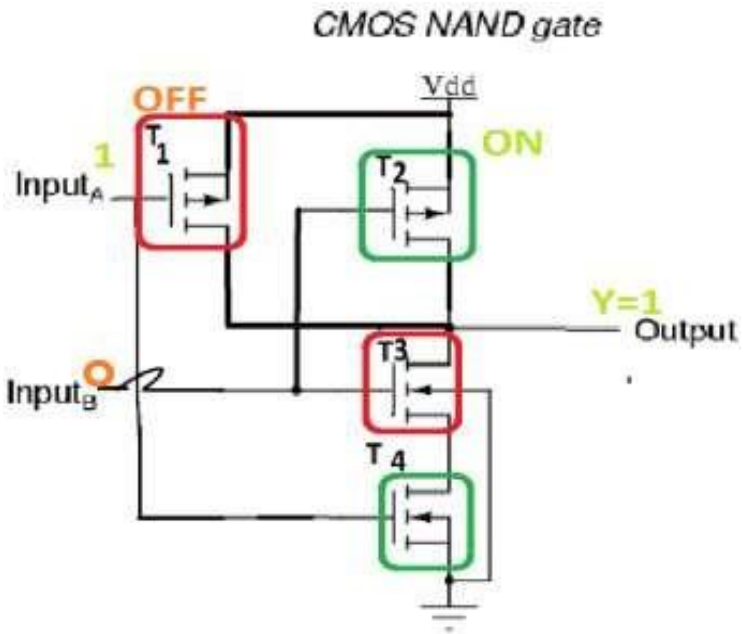


CMOS NAND GATE OPERATION

- If any one of the input is high then the pmos transistor is OFF & its Combinational nmosTransistor is On.
- For Eg:

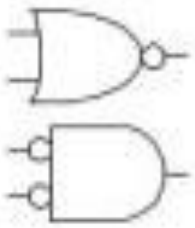
INPUT	T1	T2	T3	T4	OUTPUT
0,0	ON	ON	OFF	OFF	1/HIGH
0,1	ON	OFF	ON	OFF	1/HIGH
1,0	OFF	ON	OFF	ON	1/HIGH
1,1	OFF	OFF	ON	ON	0/ LOW

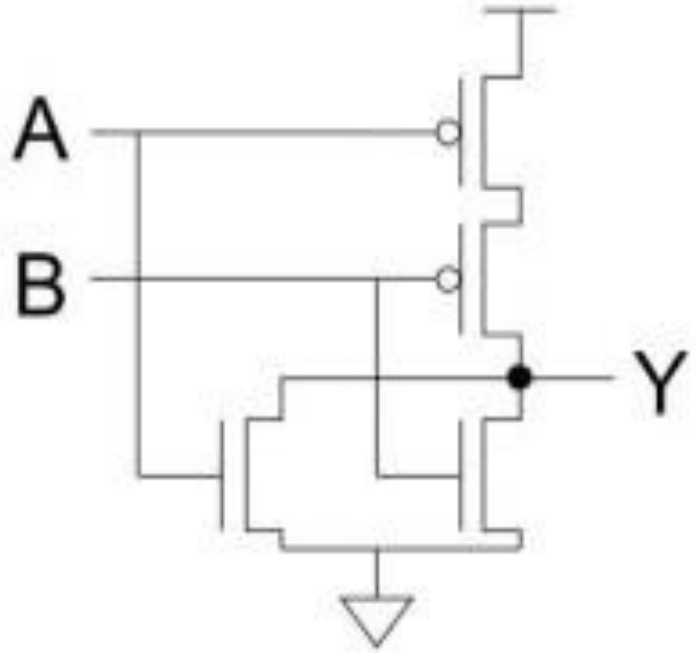




CMOS as a NOR Gate

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0





COMPARISON OF TTL and CMOS LOGIC FAMILY

Parameter	CMOS	TTL
Basic gate	NAND/NOR	NAND
Fan-out	>50	10
Power per gate (mW)	1 @ 1 MHz	1 - 22
Noise immunity	Excellent	Very good
t_{PD} (ns)	1 - 200	1.5 – 33

MCQ

. If a logic circuit has a fan out of 4 then the circuit

A. 4 input

B. has 4 outputs

C. can drive maximum of 4 inputs

D. gives output 4 times the input

A RTL consists of

A. Resistor ,transistor and inductors

B. Resistors,diodes and bipolar junction transistor

C. Resistors,capacitors and diodes

D. Resistors and transistors