UTM UNIVERSITI TEKNOLOGI MALAYSIA

SEEE 1223
DIGITAL ELECTRONICS

CHAPTER 5: INTEGRATED CIRCUITS (IC)

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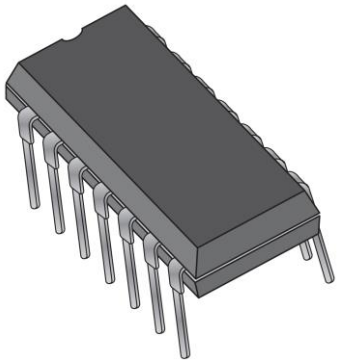
CHARACTERISTICS OF IC

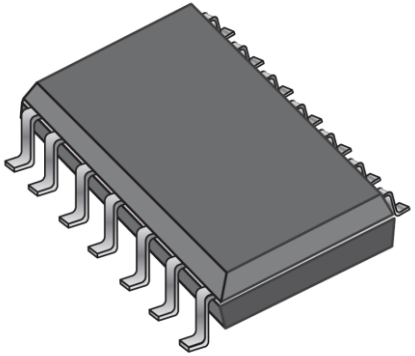
CHARACTERISTICS OF IC

PACKAGING

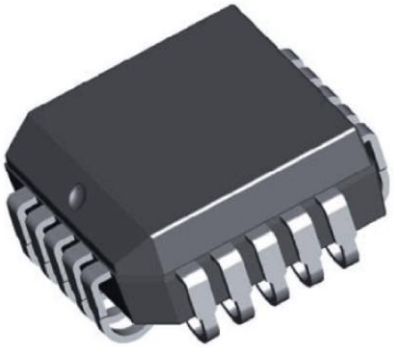
- **IC** is a group of gates that fabricated on a single chip of silicon.
- The IC comes in different shapes according to the packaging:
  - Size, operating condition and cost.
- Three types of packaging:
  - **Dual Inline Package (DIP)** - Two parallel rows of pins for plug in mounting.
  - **Small Outline IC (SOIC)** - For surface mount design.
  - **Small Outline J-lead (SOJ)** – Use J-shaped leads that curls underneath the package body (requires socket to mount)



DIP



SOIC



POCC

CHARACTERISTICS OF IC

DIP IC

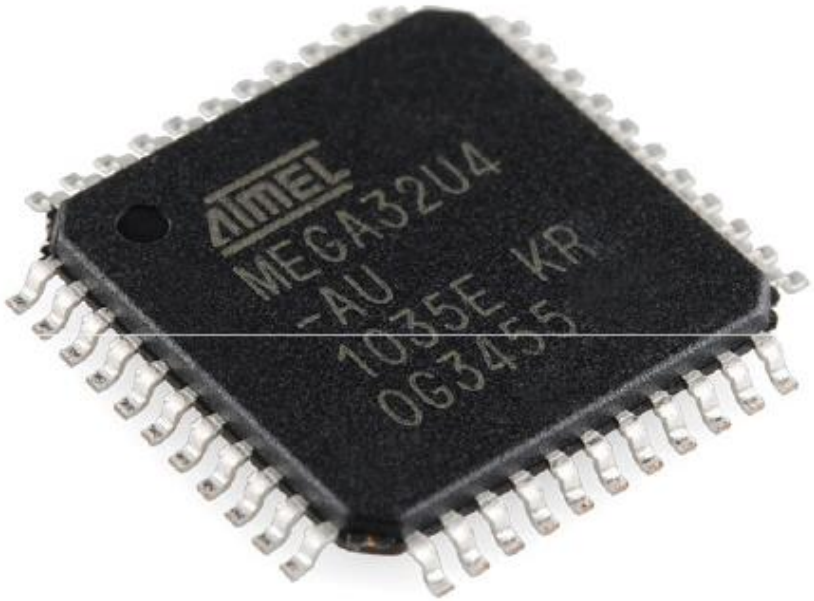
- Has two parallel rows of pins for plug and mounting.

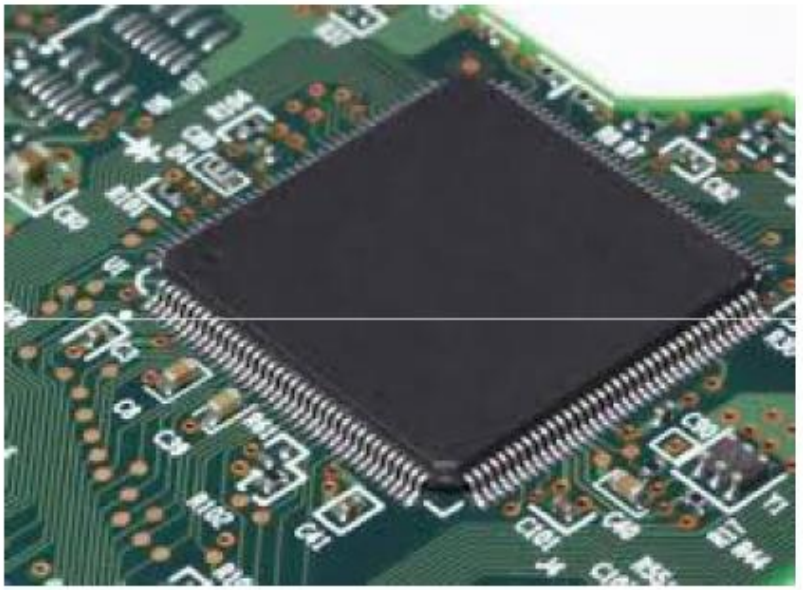
Ensure the IC is supplied with the suitable power supply to avoid IC from damage.

CHARACTERISTICS OF IC

SO IC

- For surface mounting design.





Ensure the IC is supplied with the suitable power supply to avoid IC from damage.

CHARACTERISTICS OF IC

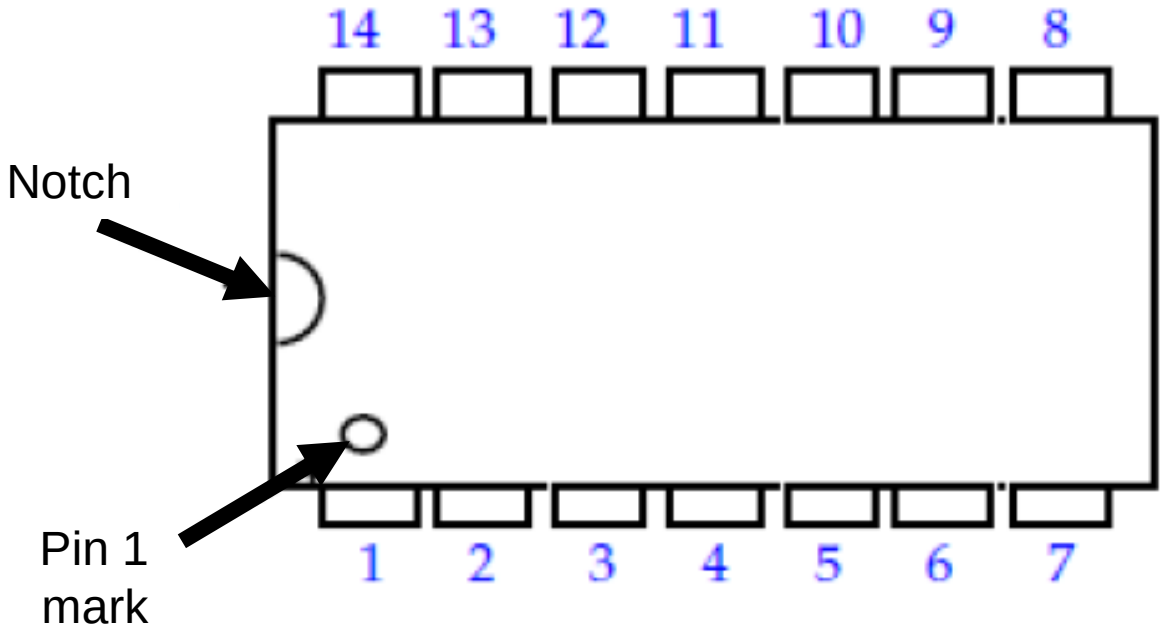
SOJ IC

- Use J-shaped leads that curls underneath the package body (requires socket to mount)

Ensure the IC is supplied with the suitable power supply to avoid IC from damage.

CHARACTERISTICS OF IC

PACKAGING

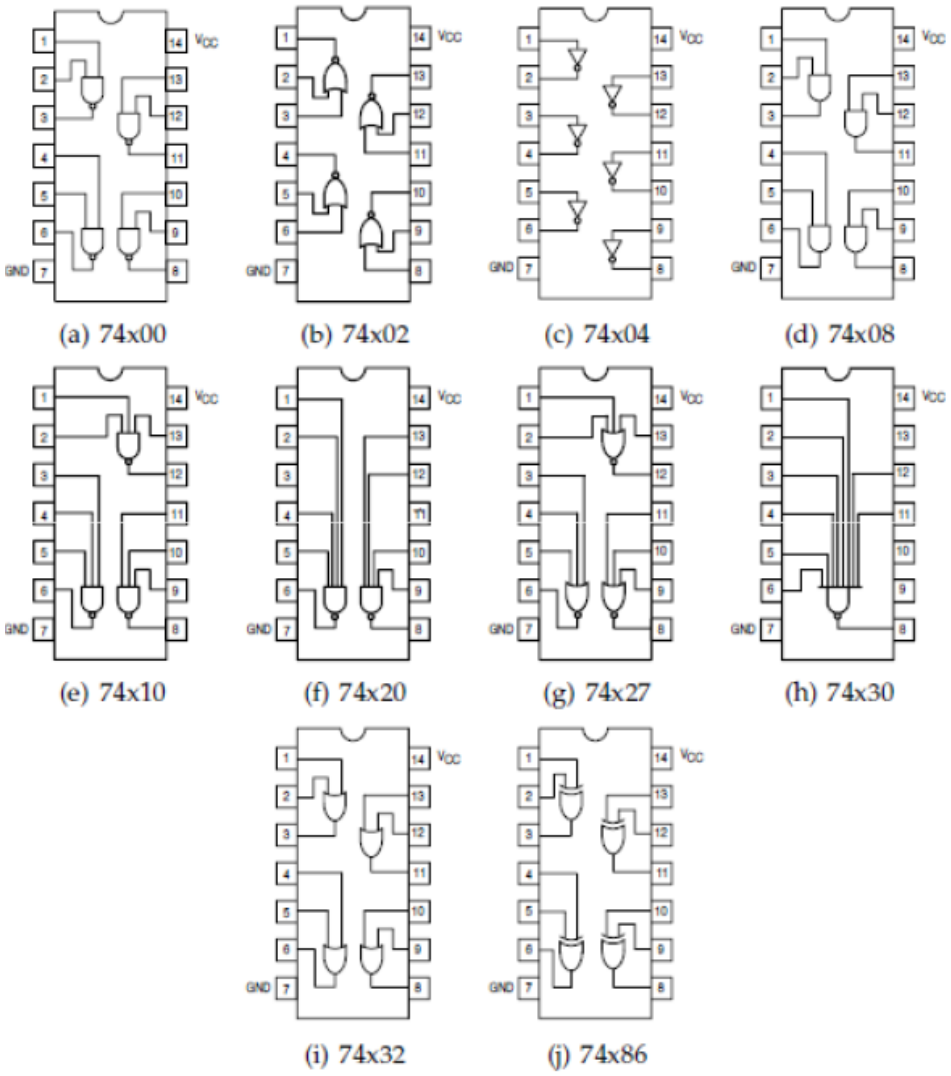


Pin-out for DIP integrated circuits

- For DIP, the pins are numbered counter clock-wise with pin 1 is located closed to the notch.

CHARACTERISTICS OF IC

BASIC GATES IN DIP PACKAGING FOR THE 74x00 SERIES



CHARACTERISTICS OF IC

IC CLASSIFICATION

- IC can be classified into **4 groups**:
  - **Small Scale Integration Circuit (SSI)**
  - **Medium Scale Integration Circuit (MSI)**
  - **Large Scale Integration Circuit (LSI)**
  - **Very Large Scale Integration Circuit (VLSI)**

IC classification by level of integration

Complexity	Acronyms	Number of gates	Example
Small scale integration	SSI	≤ 10	Individual gates
Medium scale integration	MSI	$10 - 100$	Flip flops, registers
Large scale integration	LSI	$100 - 1000$	Memories (1kB Ram)
Very large scale integration	VLSI	≥ 1000	Microprocessors

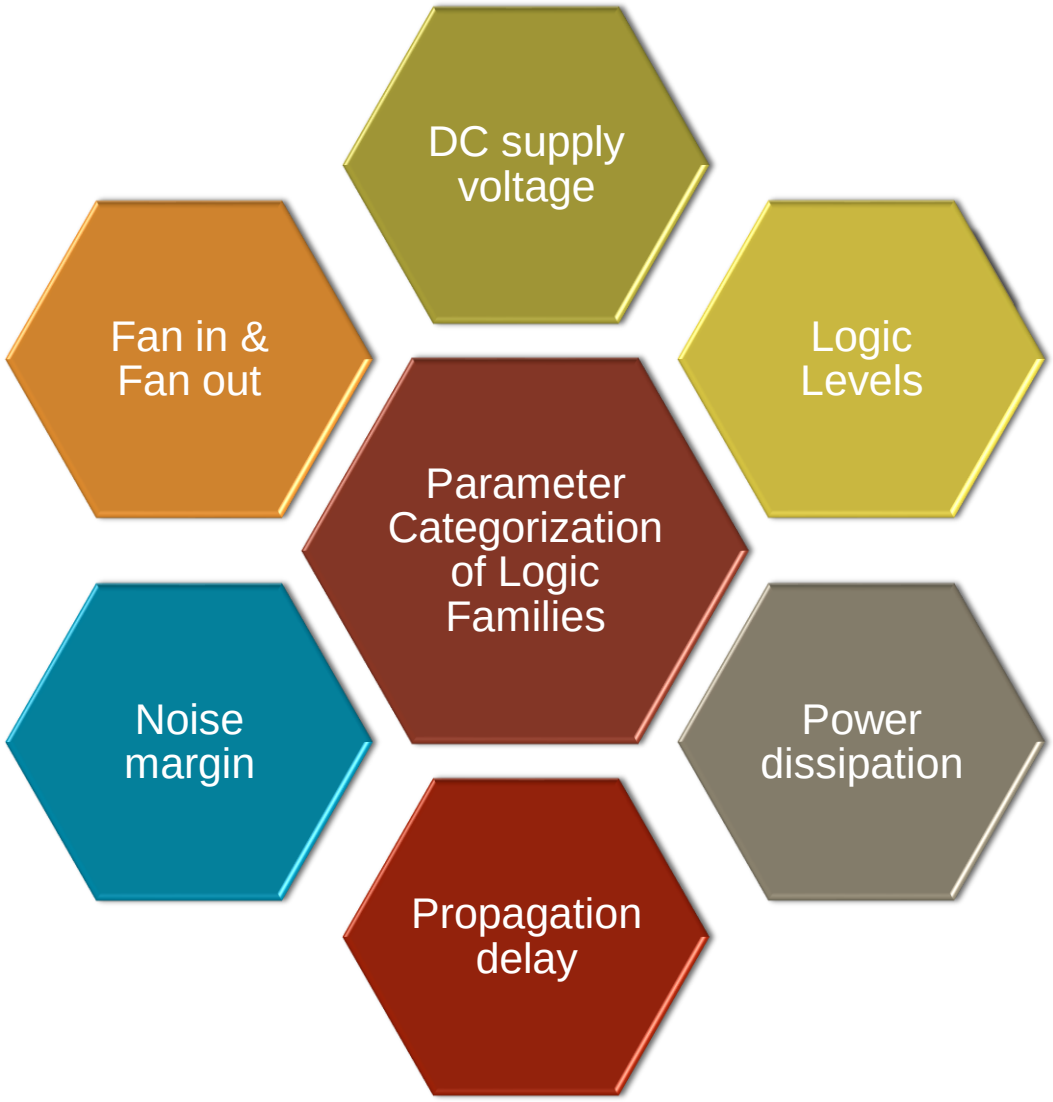
CHARACTERISTICS OF IC

LOGIC FAMILIES

- **Logic Families** is a collection of different IC that have similar characteristic.
- IC also can be categorized by the fundamental technologies used.
- Two common technologies that usually used:
  - Transistor-transistor logic (TTL)- use bipolar junction transistor.
  - Complimentary metal oxide semiconductor (CMOS)- use field-effect transistors (FET).
  - BiCMOS- combination of TTL and CMOS.

CHARACTERISTICS OF IC

LOGIC FAMILIES



CHARACTERISTICS OF IC

ACTIVE LEARNING (JIGSAW METHOD)

1. Go into your group (HOME group).
2. For each group member, please take 1 of the topic:
   i. DC supply voltage & logic levels
   ii. Power dissipation & propagation delay
   iii. Noise margin, fan in & fan out
   iv. CMOS vs TTL
3. Each student, please come out with your own note for topic explanation.
4. Then, please group out into the EXPERT group based on the topic given.
5. Discuss among the group and choose the most interactive note to be paste on the wall.
6. Go to your home group.
7. Now, you can proceed for gallery walk.

CHARACTERISTICS OF IC

IC PARAMETERS: DC SUPPLY VOLTAGE

- All digital ICs at least has **two** pins that connected to power rails.

	TTL	CMOS
Positive supply voltage	V_{CC}	V_{DD}
Negative supply voltage	GND or V_{EE}	V_{SS}

- For **TTL**, V_{CC} is $+5\ V \pm 0.5\ V$
  - A TTL gate may be destroyed if the limit is exceeded.

- The **CMOS** gates are tolerant to power supply voltage variations.
  - The power supply ranges from $+1.8\ V$ to $+18\ V$
  - ↓ Voltage, ↓ Power consumption.
  - ↑ Voltage, ↑ Speed.

CHARACTERISTICS OF IC

IC PARAMETERS: LOGIC LEVEL

- TTL and CMOS use voltages to represent logic levels. Ideally, a single voltage value is specified for each logic level.

VCC (power) → Logic 1

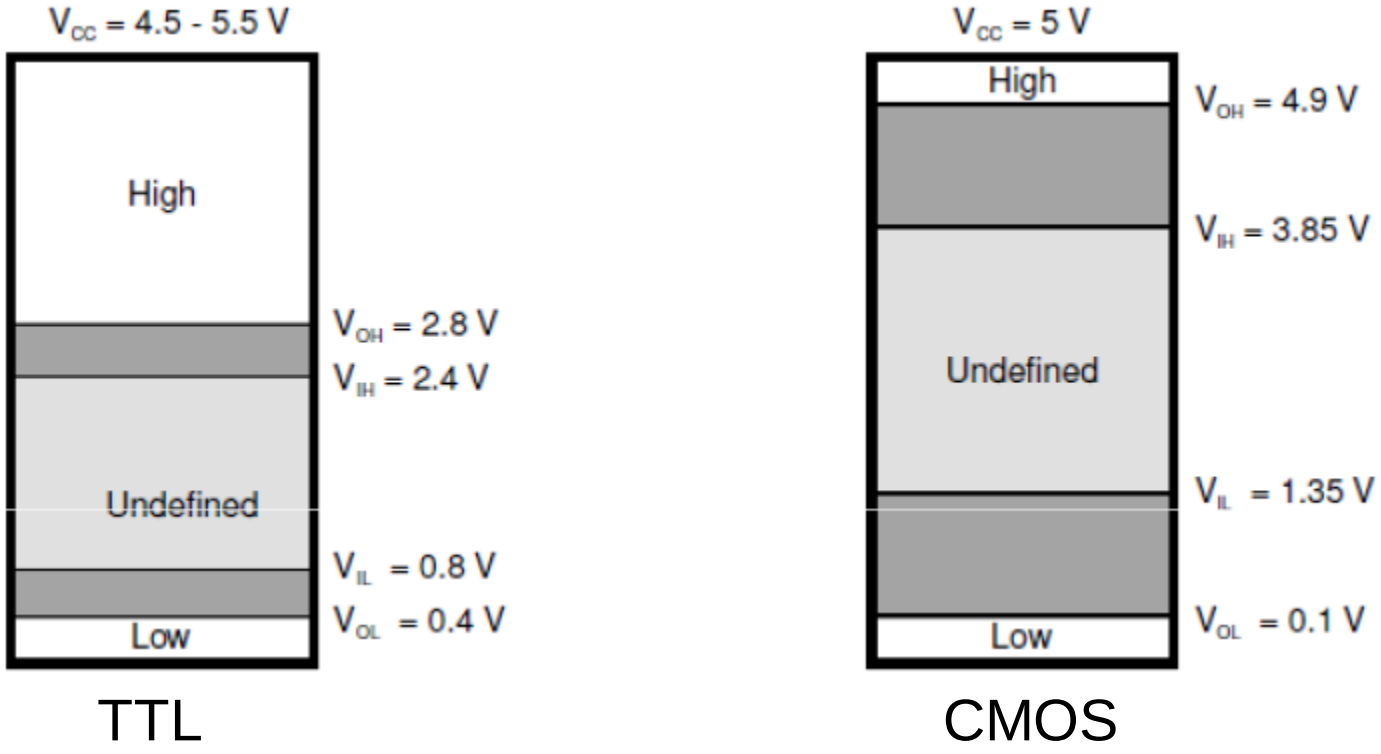
GND (ground) → Logic 0

- In reality, a range of voltages is specified for each logic level.

	CMOS	TTL
Logic 0	Less than $\frac{1}{3}V_{DD}$	Less than $0.8\ V$
Logic 1	More than $\frac{2}{3}V_{DD}$	More than $2\ V$
Indeterminate	Between $\frac{1}{3}V_{DD}$ and $\frac{2}{3}V_{DD}$	Between $0.8\ V$ and $2\ V$

CHARACTERISTICS OF IC

IC PARAMETERS: LOGIC LEVEL



- V_{IH} = Min voltage level that a logic gate will recognize as a logic 1 input.
- V_{IL} = Max voltage level that a logic gate will recognize as a logic 0 input.
- V_{OH} = Min voltage level that a logic gate will recognize as a logic 1 output.
- V_{OL} = Max voltage level that a logic gate will recognize as a logic 0 output.

CHARACTERISTICS OF IC

IC PARAMETERS: POWER DISSIPATION

- Power dissipation of gate is the supply voltage multiply by the supply current:

$$P_D = V_{CC} \times I_{CC}$$

- Note: the current value may not be the same during logic **0** and **1**. Thus,

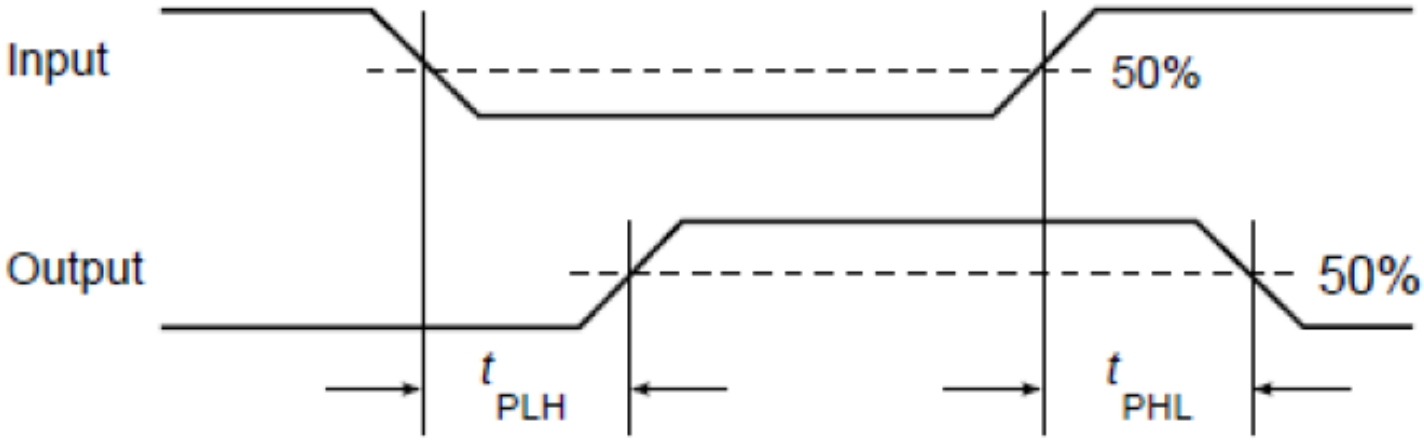
$$I_{CC} = \frac{I_{CCL} + I_{CCH}}{2}$$

- I_{CCL} is supply current during logic low and I_{CCH} is supply current during logic high.

CHARACTERISTICS OF IC

IC PARAMETERS: PROPAGATION DELAY

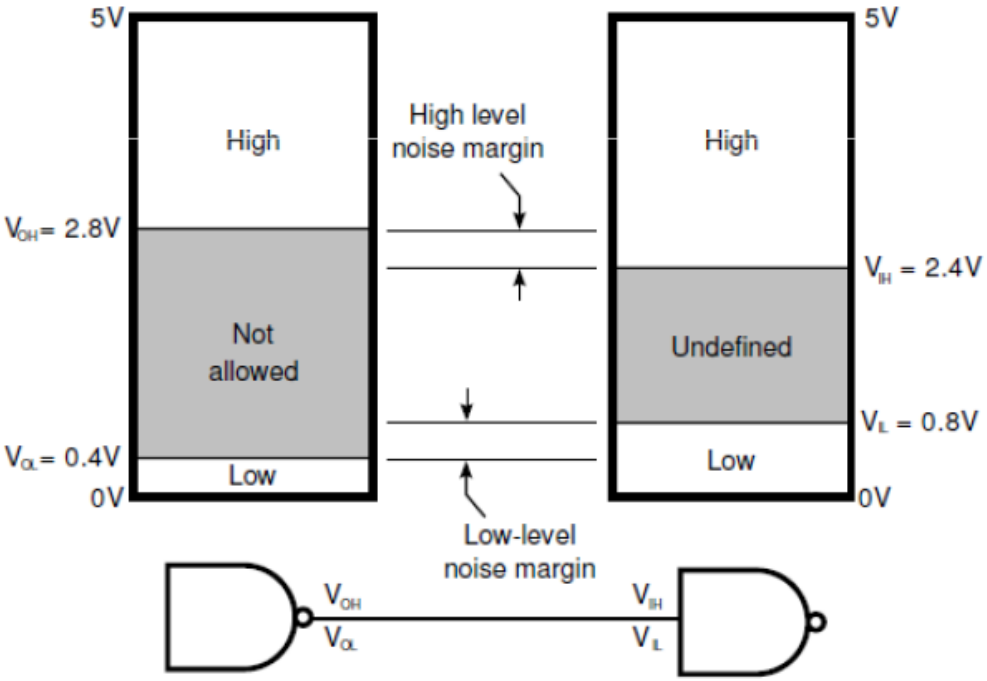
- Propagation delay is the delay from a change in input to a change on the output.
  - t_{PHL} – Delay from an input is given to the time the output changes from **high to low**.
  - t_{PLH} – Delay from an input is given to the time the output changes from **low to high**.



CHARACTERISTICS OF IC

IC PARAMETERS: NOISE MARGIN

- Noise margin is a measure of the ability of a device to reject noise.
- If the noise in the circuit is high enough, it can push a logic 0 up or drop a logic 1 down into the indeterminate or “illegal” region.



Noise Margin for logic high is:

$$V_{NH} = V_{OH} - V_{IH}$$

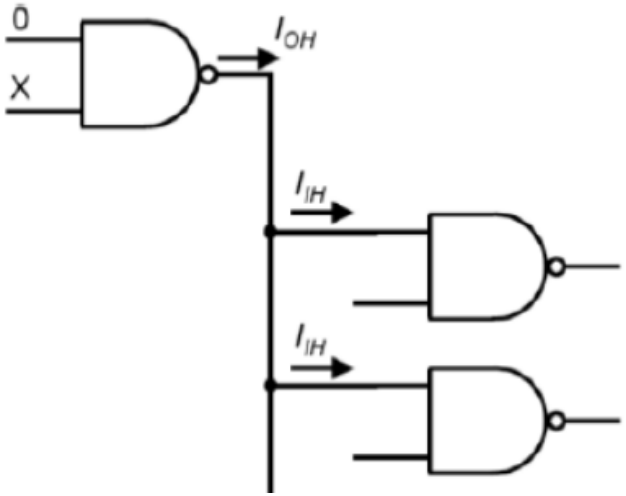
Noise Margin for logic high is:

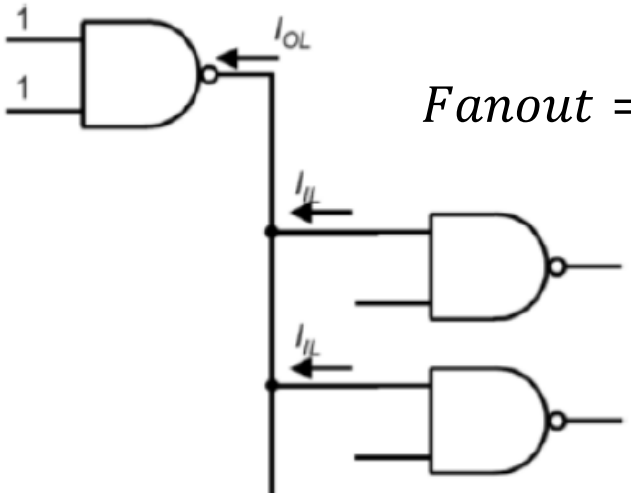
$$V_{NL} = V_{IL} - V_{OL}$$

CHARACTERISTICS OF IC

IC PARAMETERS: FAN-IN & FAN-OUT

- The Fan-out is a number of standard loads that an output can drive.
- An output can only be connected to a limited number of inputs before the signal levels deteriorates and no longer recognized a logic 0 or 1.
- Exceeding the Fan-out may result in incorrect circuit operation and may destroy the device.





$$Fanout = min\left(\frac{I_{OH}}{I_{IH}}, \frac{I_{OL}}{I_{IL}}\right)$$

CHARACTERISTICS OF IC

IC PARAMETERS: FAN-IN & FAN-OUT

- Fan-out is much higher for CMOS devices than for TTL devices.
- I_{IL} and I_{IH} are extremely small for CMOS $(< 1\mu A)$ while TTL (mA).
- Calculating fan-out might yield fan-out of 4000 for CMOS, compared to 10 for a standard TTL.
- However, increased fan-out results in increased delay due to input capacitance.
- Fan-in simply the number of inputs to a gate.

NAND gate with a fan-in of 8

CHARACTERISTICS OF IC

CMOS VS TTL

CMOS (Complementary Metal-Oxide Semiconductor)	TTL (Transistor-transistor logic)
Uses FET (Field Effect Transistor)	Uses BJT (Bi-polar Junction Transistor)
CMOS device is inexpensive	TTL device expensive
Sensitive to electrostatic discharge	Immune to damage from static electricity
Can tolerate a wide range of voltage	Requires well regulated +5V power supply
Low current required (μA)	Heavy current consumption