TTL and CMOS Technologies

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What are the differences - TTL and CMOS?

• Why is it important?

• Can I mix TTL and CMOS ICs

• An AND gate is an AND gate whether CMOS or TTL?

• Fuel is Fuel whether Petrol or Diesel?
TTL

• Stands for Transistor Transistor Logic
• digital circuits built from bipolar junction transistors (BJTs)
• transistors perform both:
  - the logic function (e.g., AND)
  - the amplifying function
• Usually come as ICs (74XX range)
• Designed in 1963
• Logic gates, flip-flops and counters
Work out the function of the following gate:
Answer:

- It is a **NAND Gate**

- Only when a 1 and 1 is applied at the i/p will the base of the o/p transistor not sinked that is it is set high. The transistor opens it’s C to E path setting the output Q to logic 0
How many transistors?

- OP Amp 741?
  2
  5
  24
  45

- 4 AND Gate IC 7438?
  4
  10
  16
  48
OP Amp 741 Transistor Count:
Inside an LM358
AND Gate – Transistor Count (x4):
Microprocessor Transistor Counts 1971-2011 & Moore's Law

The graph shows the increase in transistor count over time from 1971 to 2011. The curve indicates that transistor count doubles every two years, as per Moore's Law. The x-axis represents the date of introduction, while the y-axis shows the transistor count. Various Processor models and manufacturers are marked on the graph, illustrating the progress in semiconductor technology over the decades.
The Boy and his Atom! 2Min

- https://youtu.be/oSCX78-8-q0

- Making of the film 5min:
  https://youtu.be/xA4QWwaweWA

- How to move an Atom:
  https://youtu.be/rNf-A3m6HV0

- The sound of moving Atoms:
  https://youtu.be/FbLvy-ayi4A
IC – Integration Levels

• **Small Scale Integration or (SSI)**
  - Contain up to 10 transistors or a few gates within a single package such as AND, OR, NOT gates.

• **Medium Scale Integration or (MSI)**
  – between 10 and 100 transistors or tens of gates within a single package and perform digital operations such as adders, decoders, counters, flip-flops and multiplexers.

• **Large Scale Integration or (LSI)**
  – between 100 and 1,000 transistors or hundreds of gates and perform specific digital operations such as I/O chips, memory, arithmetic and logic units.
IC Integration Levels

• **Very-Large Scale Integration or (VLSI)**
  – between 1,000 and 10,000 transistors or thousands of gates and perform computational operations such as processors, large memory arrays and programmable logic devices.

• **Super-Large Scale Integration or (SLSI)**
  – between 10,000 and 100,000 transistors within a single package and perform computational operations such as microprocessor chips, microcontrollers, basic PICs and calculators.

• **Ultra-Large Scale Integration or (ULSI)**
  – more than 1 million transistors – the big boys that are used in computers CPUs, GPUs, video processors, micro-controllers, FPGAs and complex PICs.
TTL Characteristics

• High Propagation delay
• Current operated device
• Less sensitive to EMI, Noise and Static
• High power consumption
• Generating more heat
• Strictly 5V supply voltage
Logic Levels:

- **Logic “1”**: $V_{CC} = +5V$ to $5.25V$ max, $4.75V$ min
- **Logic “0”**: $V_{CC} = +5V$, $V_{on}(min) = 2.0V$, $V_{off}(max) = 0.8V$

Indeterminate Region:
- $V_{on}(min) = 2.0V$
- $V_{off}(max) = 0.8V$

LS - TTL Input Voltage Levels:
- $0V$

LS - TTL Output Voltage Levels:
- $0V$
Discuss:

• Why is there a difference between input and output levels.

• What are the two jobs an IC has to do to maintain the logic signals?

• What happens when you transfer a signal?
CMOS Technologies

- Gates based on field effect transistors FETs
- “CMOS” (Complementary Metal Oxide Semiconductor)
- Gates use both P-channel and N-channel MOSFET’s
- Almost no power consumption
- Less heat generated
- Ideal for large scale integration
- Statically sensitive
- Voltage operated device
- Supply voltage 3V to 18V
- Introduced early 70s
- ICs are labelled 40XX
CMOS Levels:

**Acceptable CMOS gate input signal levels**
- High: 5 V, 3.5 V, 1.5 V, 0 V

**Acceptable CMOS gate output signal levels**
- High: 5 V, 4.95 V
- Low: 0.05 V, 0 V
TTL CMOS Level Conversion

Acceptable TTL gate input signal levels:
- High: 0 V - 2 V
- Low: 0.8 V - 0 V

Acceptable TTL gate output signal levels:
- High: 2.7 V - 5 V
- Low: 0.5 V - 0 V

Acceptable CMOS gate input signal levels:
- High: 1.5 V - 3.5 V
- Low: 0 V - 0.05 V

Acceptable CMOS gate output signal levels:
- High: 4.95 V - 5 V
- Low: 0 V - 0 V
TTL to CMOS Converter CD4504:

Hex Voltage Level Shifter (from TI)
When would you choose to use TTL instead of CMOS technology?

• Look at industry needs

• Consider where logic circuits are required?

• Consider situations where would CMOS technology be better used?
Consider:

- EMI
- Intrinsically safe environment
- Large scale integration
- Need for low power circuits – solar operated, battery operated, etc.
- False triggers
- Statics
- Cost
- Reliability
We looked at:

**TTL and CMOS technologies**

- Both used for digital logic circuits including:
  - gates
  - flip flops (memory)
  - counters
- Both technologies have different V for logic 1 and 0
- To mix CMOS and TTL logic devices we would need a level converter
- There are distinct advantages and disadvantages for either technology