LOGIC CIRCUIT FAMILIES

74xxx

ICs

Analog Digital

logic gates ← family

- Logic circuits come in families.
- The members of a logic family are compatible to the *n*th degree, which is what the family is all about. interface
- All the members of a logic family have very similar characteristics. — delay

F_1 F_2

logic 1 → range of vol.

- All require the same power supply voltages.
- All respond to the same logic signal levels. 1 0
- All produce the same signal levels. All of them operate at similar speeds.
- The members of a logic family are designed to work together simply.

1. same voltage supply
2. range is identical
3. delays are same
4.

- In most cases, a signal is moved from one member to another "just by running wires." You don't have to pay attention to signal levels, voltages, or drive currents.
- You do, however, have to consider timing, because a signal that arrives with too much delay may not cause the desired operation.
- Two families are quite common because they are simple, cheap, and versatile.
- They are also fairly forgiving of wiring errors.

TTL Family

John/Jack Kilby

JK

Transistor - Transistor -

- The transistor-transistor logic family (TTL) has been around for over 70 years. The two Ts in the name tell a little about the physical arrangement of the internal components. IC

normal, fast, low power, High speed

- Part labels generally begin with a number, either 74 (commercial grade parts) or 54 (military grade).

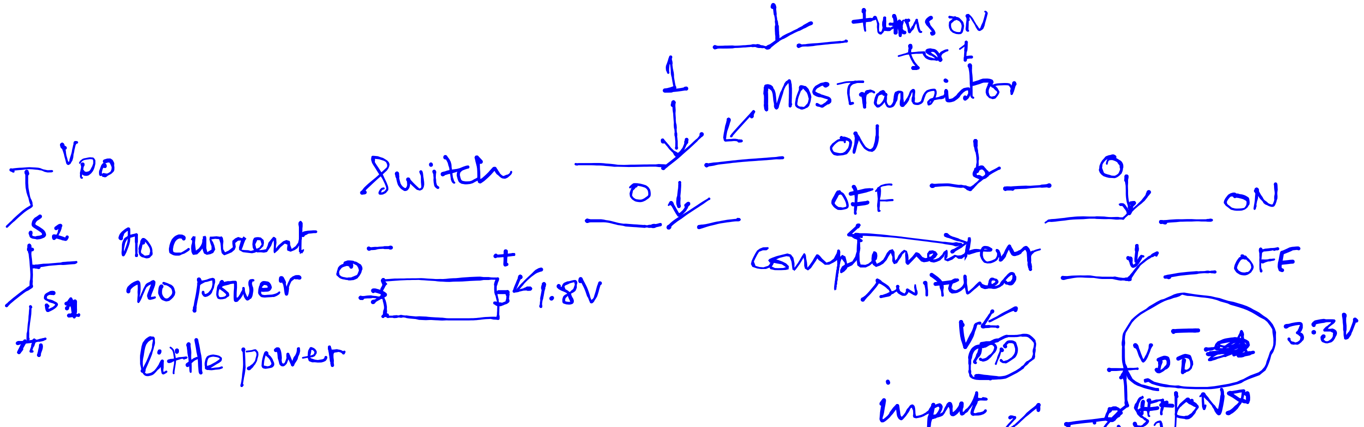
various configurations

- Within the TTL family are several subfamilies, separated by such characteristics as power consumption and speed.
- The particular subfamily is designated by letters after the initial number. Two examples are 74LS series (low-power Schottky), which are simple, require relatively small amounts of power, and operate at moderate speed, fast enough for many applications (such as vending machine logic).
- 74F series (fast), which are faster than the 74 LS series. These, and others that are even faster, may found in such systems as printers.
- The blank after the letters is filled in with two to four digits. But the digits are the same for standard circuits. For example, 74LS00 and 74F00 are both chips containing four two-input NAND gates.

1.8V → 1.2V

- The TTL family typically requires a 5-volt power supply.

CMOS Family



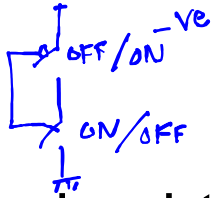
- The CMOS logic family (complementary metal-oxide semiconductor) is a very low-power family of chips.
- Typical power consumption when the chip isn't doing anything is in the microwatt range.
- The members of this family require essentially zero power except during switching, which means that their average power consumption depends on how many times the output switches per second. In other words, power consumption is proportional to frequency.
- There are three subfamilies here:
- 40 series, which was the original family. Its devices are moderately fast.

CMOSFamily

- 74HC series (high-speed CMOS), which is popular and has many different types of devices available. But it, like the 40 series, will not interface easily with the members of the TTL family. Yet we sometimes need to do this because the CMOS families do not have as many varieties of logic devices, something I am not going to cover in this text.
- 74HCT (high-speed CMOS, TTL compatible), which resolves that problem. But here too, the variety is not very extensive.
- As with the TTL families, standard numbering is used. So a 4000, a 74HC 00, and a
- 74HCT 00 all have four NAND gates on one chip.
- CMOS has another advantage—lower power supply voltages. While 5 volts is still common, 3.3 volts, 3 volts, and even less than 3 volts are available.
- So where does this get us? Just the facts. What I've just covered is mostly background information so that, when you encounter the chips of the real world, you won't be totally illiterate!

Logic Circuits and Binary Levels

current
higher to lower

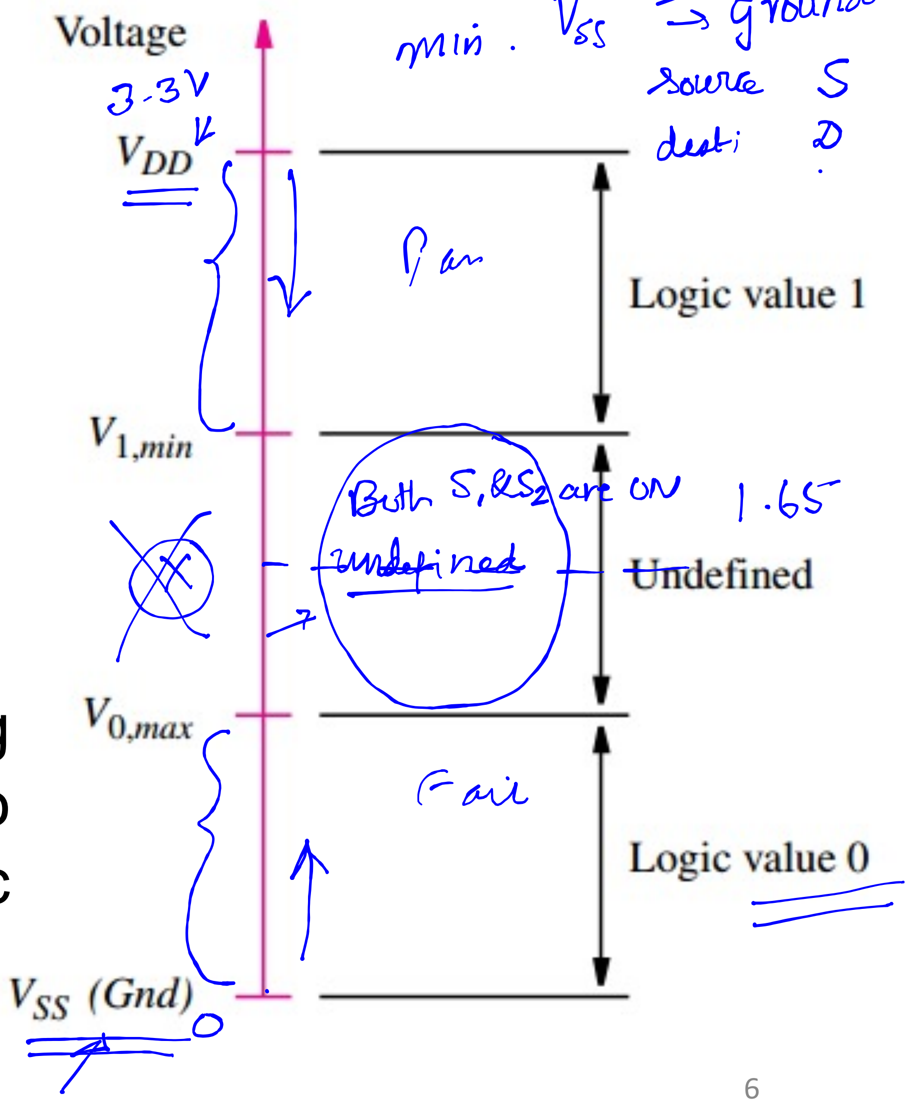


max. V_{DD}
min. V_{SS} → ground
source S
desti D

Any circuit in which the signals are constrained to have only some number of discrete values is called a *logic circuit*.

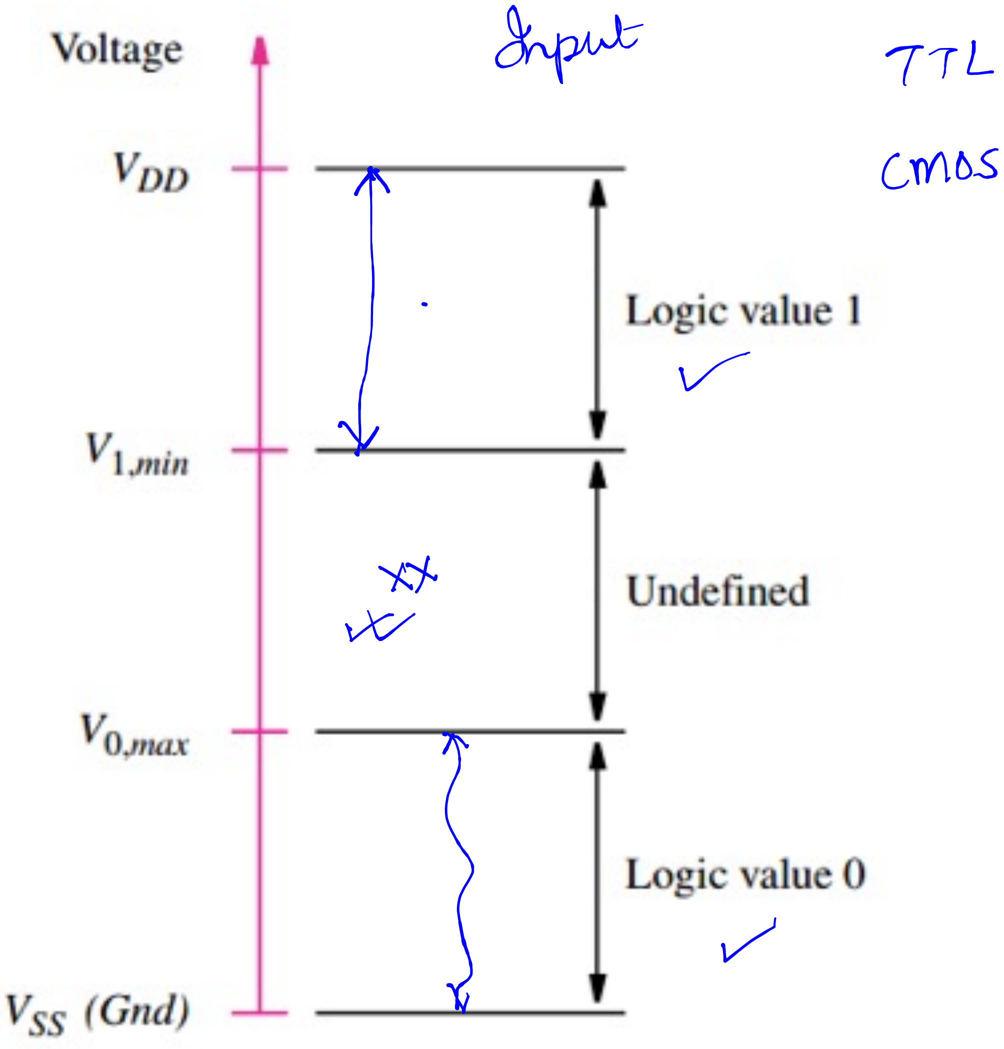
When we deal with systems with only two levels and it is called Binary Logic, in number system we call them binary numbers.

When we talk about electronic circuits realizing logic functions there, to a first thought only two levels or two voltages representing the two logic values.

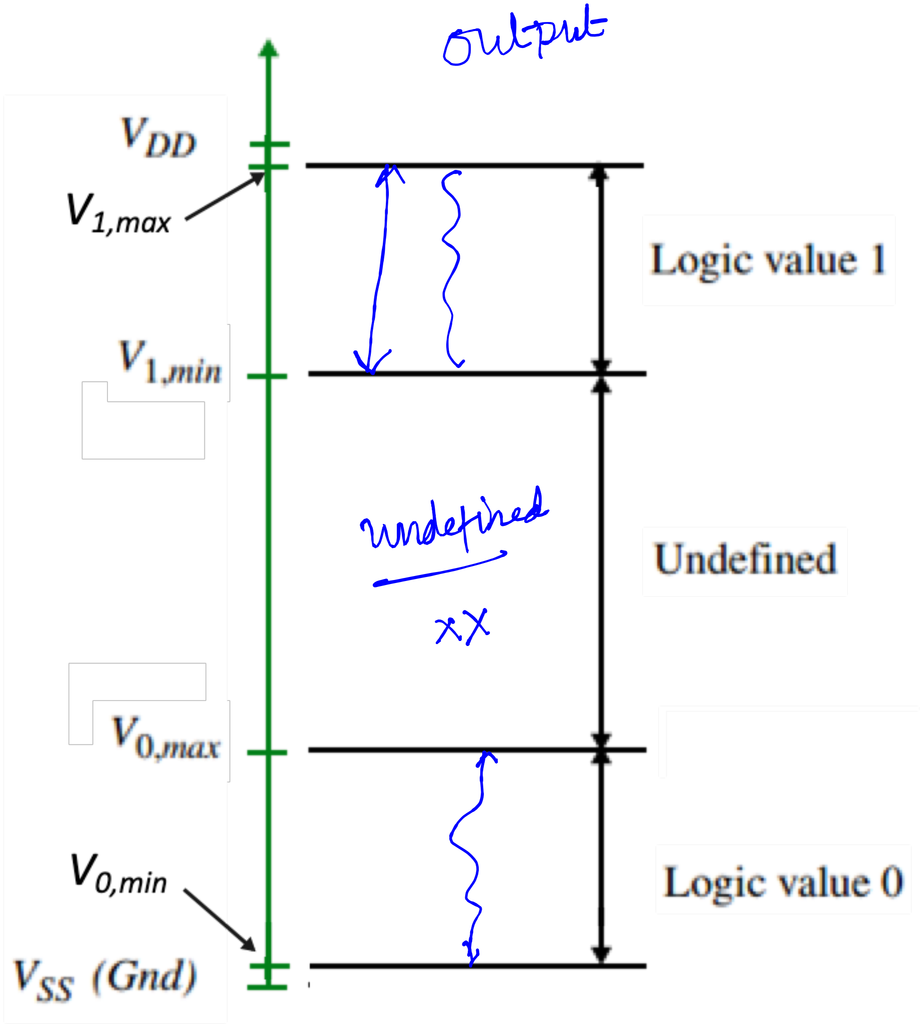


Logic Circuits and Binary Levels

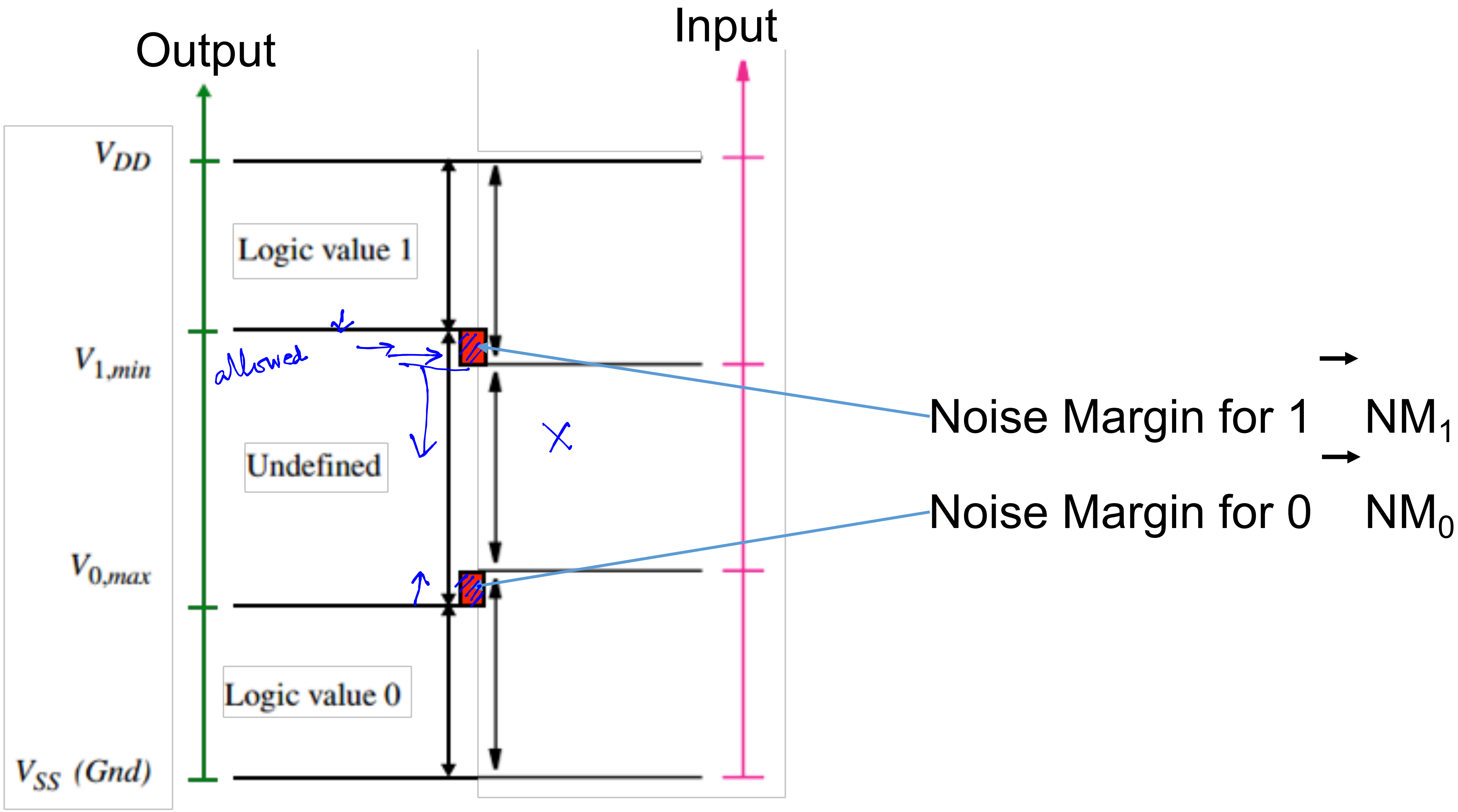
Recognize at the input:



Available at the output:



Logic Circuits and Binary Levels



TTL: Transistor Transistor Logic:

CMOS: Complimentary MOS Logic:

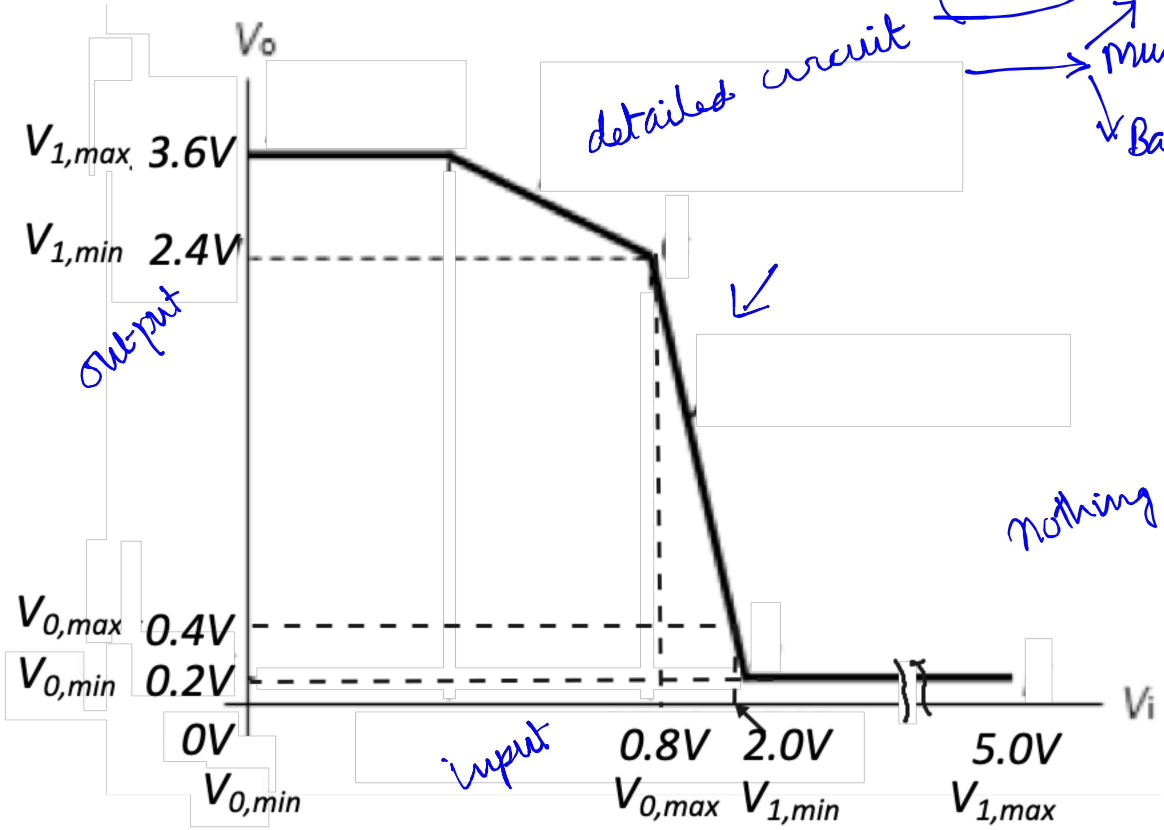
$V_{DD} = 5V$

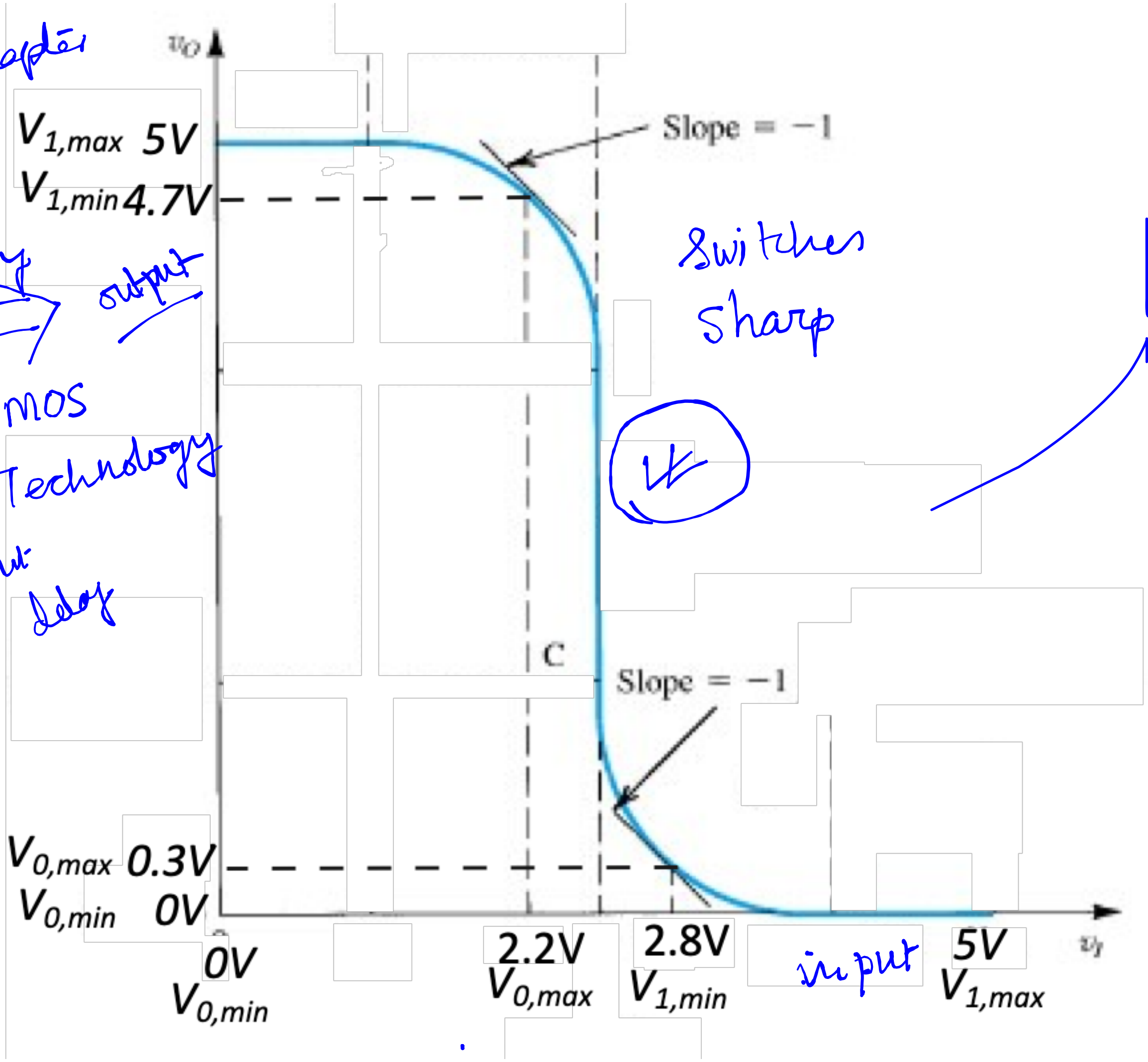
detailed circuit → ripple → ac adapter → music → Battery

⇒ output

CMOS Technology

nothing about delay





Switches sharp

SUMMARY

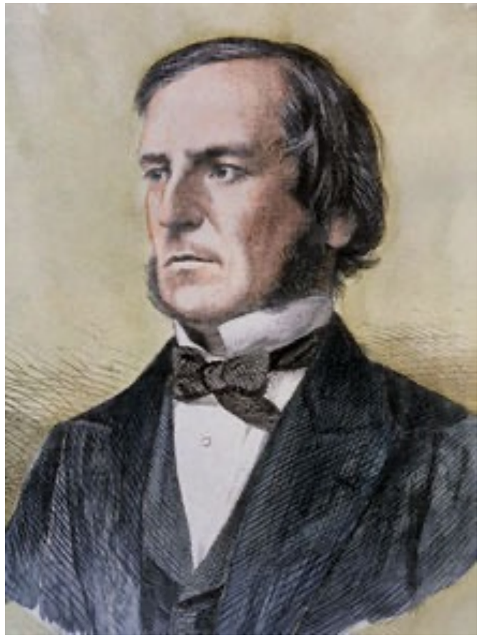
You've seen three logic circuits.

- After looking into what digital systems are, we designed a combinational circuit for the turn signals. We started with an
  - ➢ incompletely-specified word problem,
  - ➢ produced specifications,
  - ➢ reduced these to a truth table, and
  - ➢ created a logic circuit to do the job.
- Combinational circuits have no memory—sequential circuits do.
- We added a flasher to the turn signals,
  - ➢ proceeding from the specifications
  - ➢ to the State Diagram/Table to the Transition/Excitation Table
  - ➢ finally to the logic circuit and flip flops (memory)
- And what's next? A brief look at, numbers and arithmetic, mostly in binary, and codes, Boolean Algebra ------ only briefly.

or

Binary

Boolean Algebra (Developed by George Boole --- 1854)



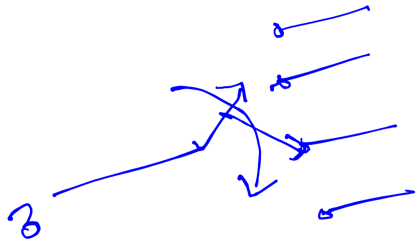
two valued

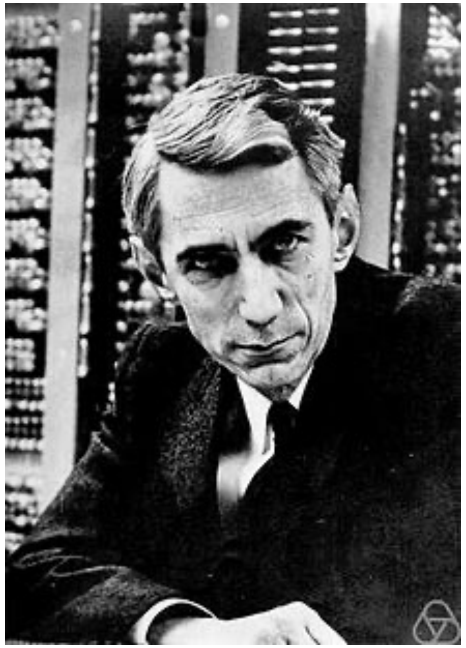
analyse logic or human thought

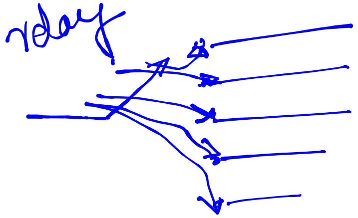
theory

- *"Mathematical Analysis of Logic"* by George Boole (1847) ----
- *An Investigation of the Laws of Thought* (1854)
- Augustus De Morgan
- Charles Sanders Peirce

Claude Elwood Shannon



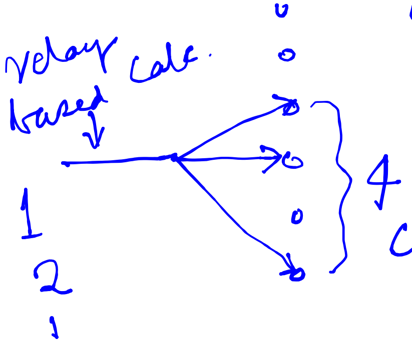




old telephone

Computing with relays

Controlled Switch



$1+2+1=4$

Computer
Calculator

- In the 1930s, while studying switching circuits, Shannon realised that Boolean algebra could be used to simplify electro mechanical relays
- He was the first to use Boolean (switching) algebra to construct digital circuits
- Father of Information Theory

Boolean Algebra

- Design and analysis of logical networks
- Set of rules to simplify (fewer gates) given logic expressions without changing its functionality (i.e. truth table)
- These rules are derived from a small number of basic assumptions. These assumptions are called axioms (postulate) no proof needed

basis

Boolean Algebra

Any mathematics begins with an invention of some kind. Boole invented the basis for his algebra by forming a series of postulates or axioms upon which he built the rest of the algebra. One form of these contains five postulates that relate very nicely to what we'll need for developing digital logic circuits.

Basic Operations: NOT ($\bar{\ }$), AND($\cdot$) and OR($+$) $B\{0,1\}$

complement

Postulates

P1: The operations are closed.

$x, y \in B\{0,1\}$ $x \cdot y \in B\{0,1\}$; $x \cdot y \in B\{0,1\}$; and $\bar{x} \in B\{0,1\}$

belongs to

P2: For every operation there exists and identity element

$$x \cdot 1 = x \qquad x + 0 = x$$

Postulates

$3 \times 4 = 4 \times 3$

P3: The operations are commutative.

$3+4 = 4+3$ $\quad x + y = y + x \quad$ *and* $\quad x \cdot y = y \cdot x$

P4: (a) The operator $(\cdot)$ is distributive over $(+)$; i.e., $x \cdot (y + z) = (x \cdot y) + (x \cdot z)$

(b) The operator $(\cdot)$ is distributive over $(\cdot)$; i.e., $x + (y \cdot z) = (x + y) \cdot (x + z)$

next class Postulate rule

P5: For every element $x \in B$, there exists an element $\bar{x} \in B$ (called complement of x) such that $(a) x + \bar{x} = 1$ and $(b)\ x \cdot \bar{x} = 0$

P6: There exist at least two elements $x, y \in B$ such that $x \neq y$.