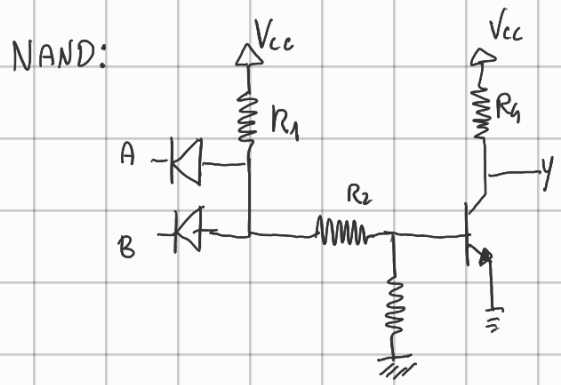
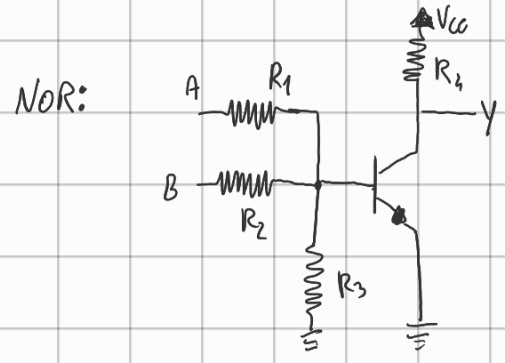


We have 4 different technology logics:

- DTL, diode transistor logic.



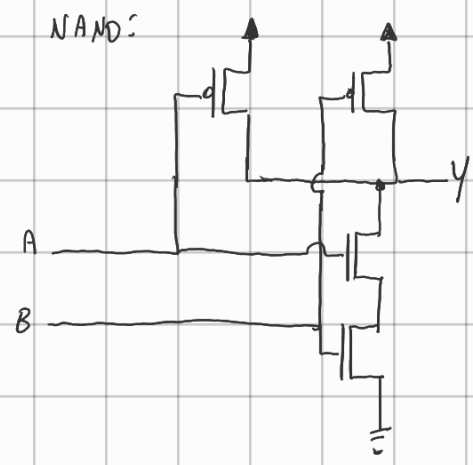
- RTL, resistor transistor logic



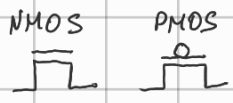
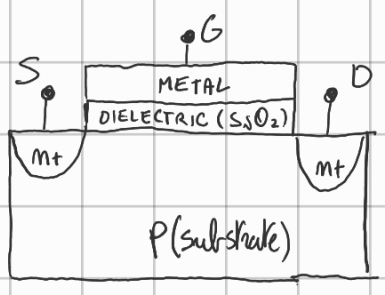
- TTL, transistor transistor logic



- CMOS: complementary MOS



NMOS: How it is done; The P-MOS is the opposite in drawing.

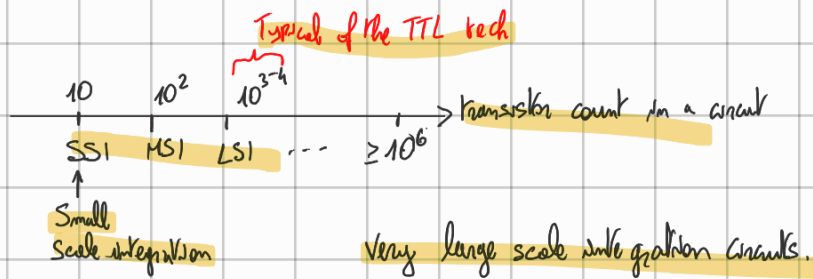


CMOS tech is the dominant because it allowed to increase the density of transistors in circuits. This tech also allows to create on the same piece of silicon a complete circuit.



All those parts on the same chip with CMOS tech.

- We started from  $\mu\text{m}$  in the late 80s and reached  $\sim \text{nm}$ . Smaller transistors also have less time of propagation.



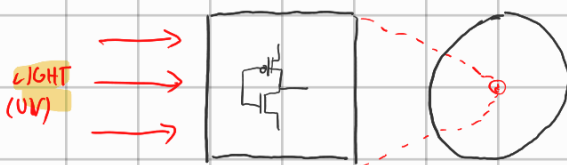
- SSI and other circuits were designed by hand. Now it is automated. This is possible using tools called Electronic Design Automation.



Most circuits today are designed with HDL code. EDA tools then gives you the geometry to realize the chip.

## HDL: Hardware description language

Chips are made use photolithographic processes, using light. To realize circuits on a disk of Silicon we use a mask.

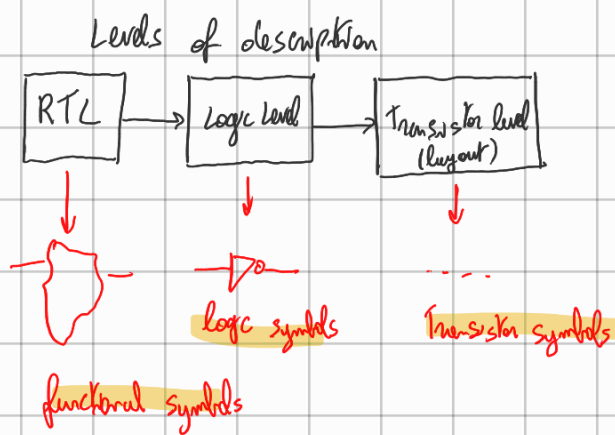


An EDA gives you the description of the mask (the LAYOUT)

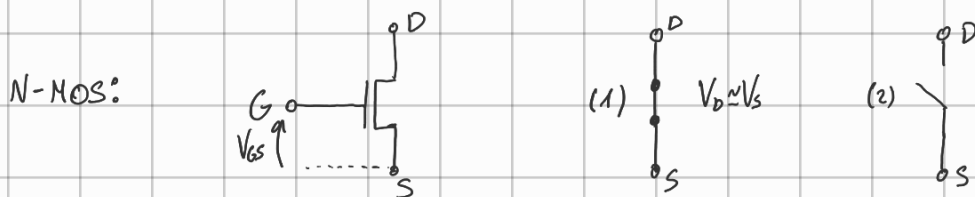
RTL: register transfer level; is a representation of input and output, graphical representation. Circuit is described by the use of registers and black boxes between registers: (just saying what the circuit does)



Another representation is LOGIC LEVEL.



## HOW TRANSISTORS WORK:



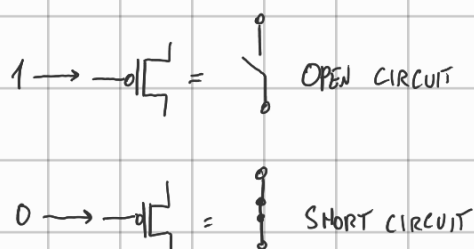
$V_{GS}$  = Voltage between gate and source. If  $V_{GS} \geq V_T$  (threshold voltage) then the transistor behaves like a short circuit (1). If  $V_{GS} < V_T$ , the transistor behaves like an open circuit (2).

In a digital circuit we work between the voltages of 0 and  $V_{CC}$ . In general, with CMOS tech the logic values work like this:

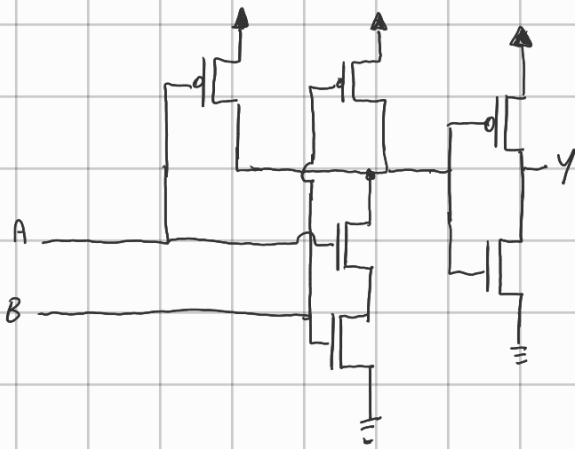


- KEEP IN MIND: If you apply logic 1 to the gate of NMOS,  $V_{GS} = V_{CC}$ , which is greater than  $V_T$  so we have a short circuit. If I apply a 0 we have an open circuit.

A PMOS transistor works the opposite:



DEFINITION: Active low signals are signals interpreted as active when low. Comparator says 0 when 2 signals are equal (mündl. mitmou e. Wspanno)



AND gate.