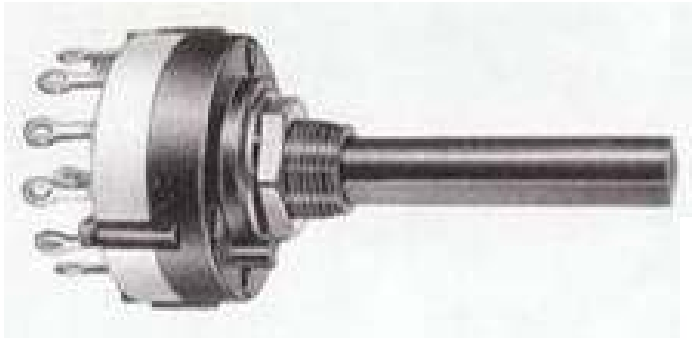
EE251
Lectures

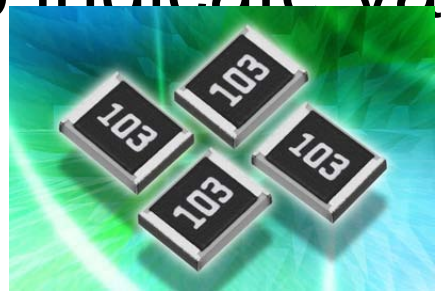
Electronic Components

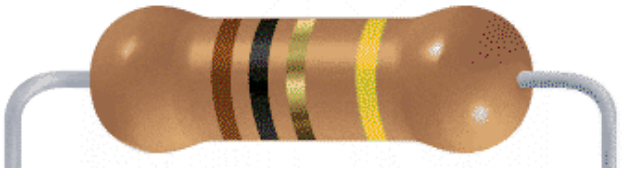
Section 03

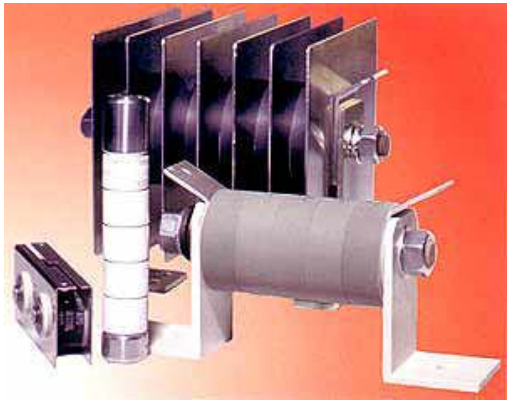
Resistors

- *Resists* the movement of electrons
- Measured in Ohms Ω
- Have colored rings to indicate value









Resistance of Elements

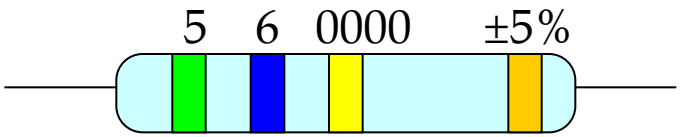
- Many loads act like pure resistors:
  - Heater Bars
  - Lamps

- But not all:
  - Most Rotating Machines
  - Florescent Lights

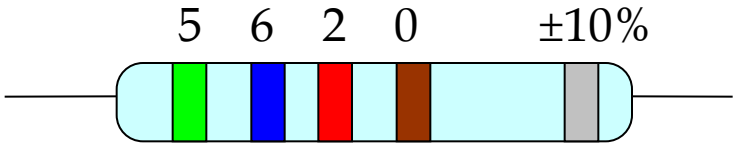
Resistors

0 black	1 brown	2 red	3 orange	4 yellow
5 green	6 blue	7 violent	8 gray	9 white

- ✓ 10 kΩ
- ✓ 470 Ω
- ✓ 33 kΩ



560, 000 Ω or 560 *k*Ω
tolerance 5%



5620 Ω or 5.62 *k*Ω
tolerance 10%

Resistors

- Power Rating
  - ¼ Watt, ½ Watt, …
- Temperature Variation
  - 10ppm, 500ppm, …
  - $R = f(\mathrm{T})$ →

$$R = R_0 \times (1 + \alpha \cdot \Delta T)$$

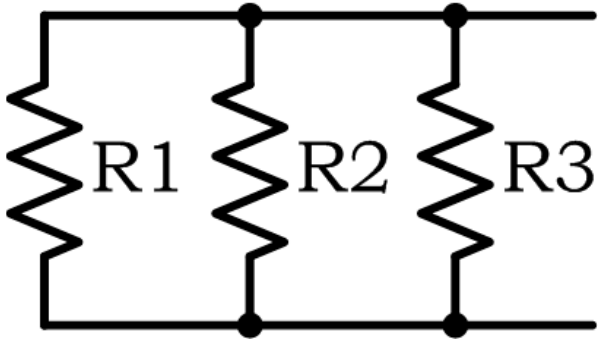
$$R = R_0 \times (1 + \alpha \cdot \Delta T + \beta \cdot \Delta T^2)$$

$$R = R_0 \times e^{\left(\frac{B}{T} + \frac{B}{T_0}\right)}$$

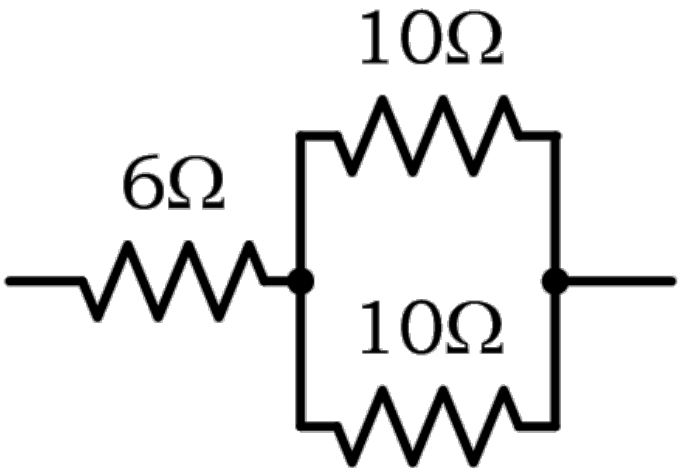
Parallel and Series

- More Resistance vs. More Admittance

$$R_T = R_1 + R_2 + R_3$$

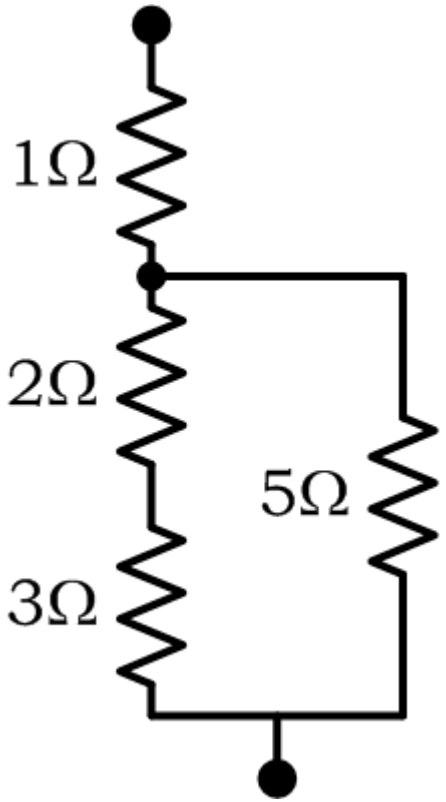


$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$



$$R_T = 6 + \frac{1}{\frac{1}{10} + \frac{1}{10}} = 6 + \frac{10}{2} = 11\Omega$$

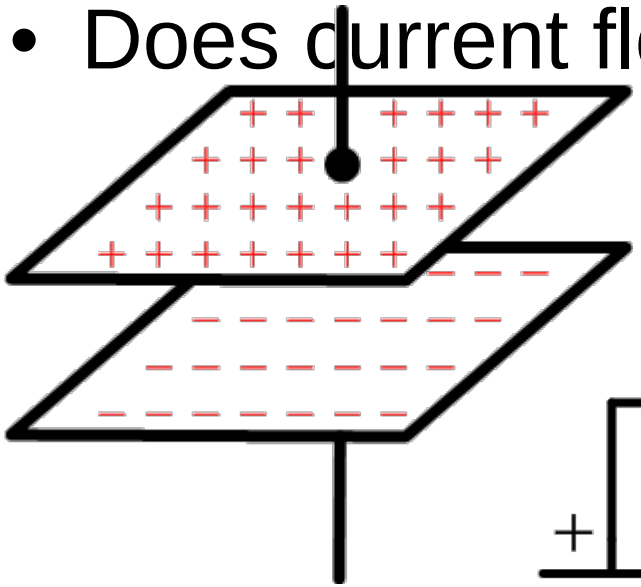
Examples

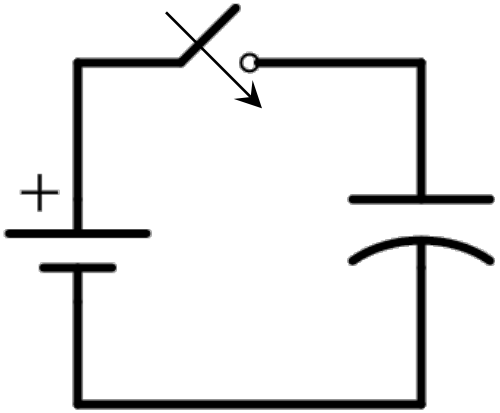


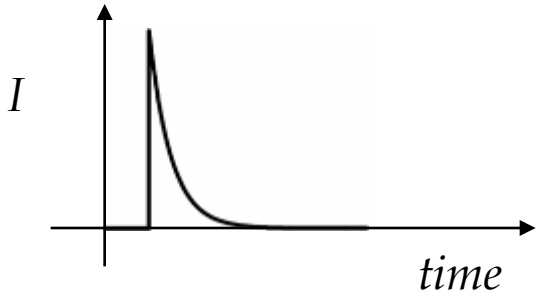
$$R_T = (2+3)//5+1 = 3.5\Omega$$

Capacitors

- Temporary Charge Storage Device
- Measured in Farad (F)
- Does current flow through a capacitor?

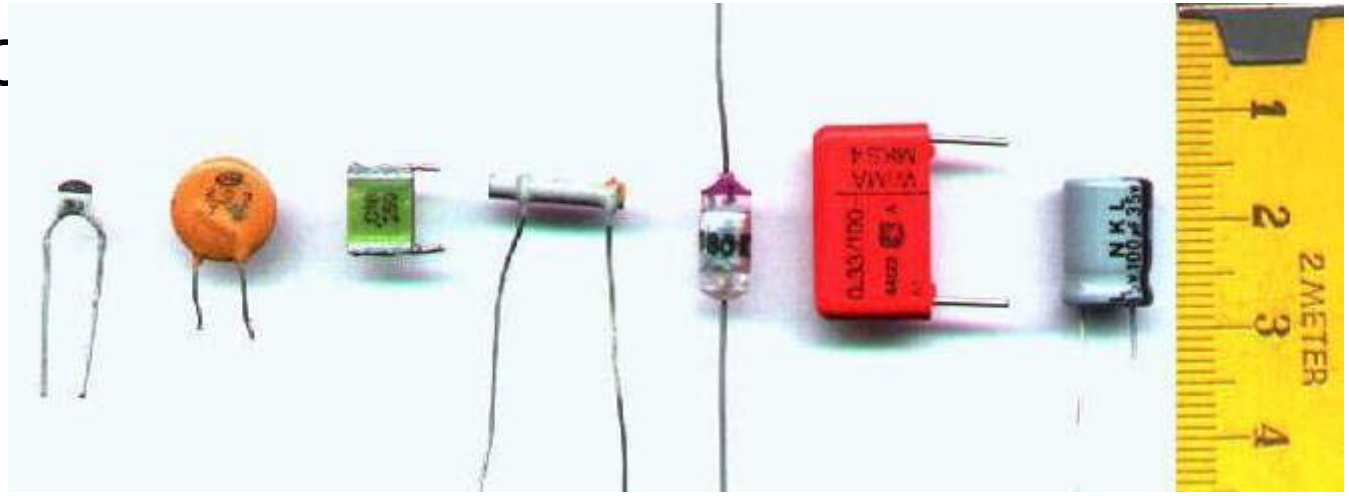




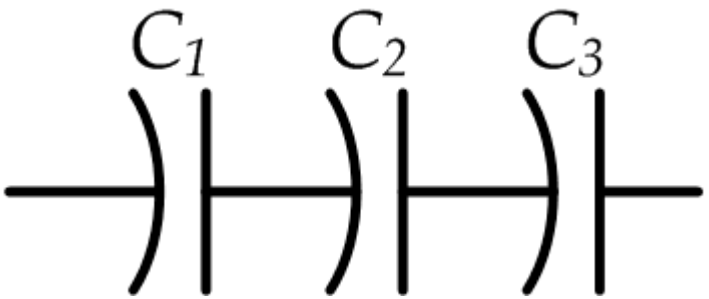


Capacitors Applications

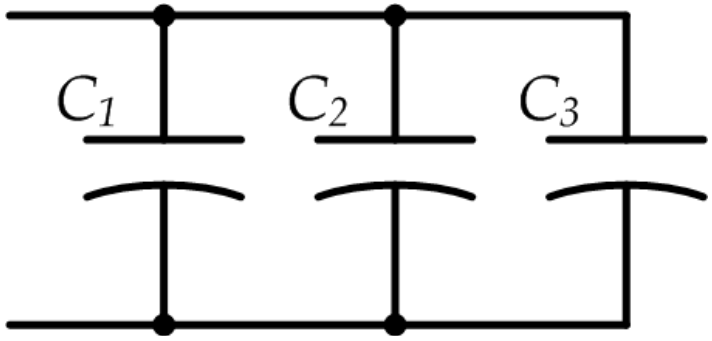
- to block DC
- to filter noise
- to smooth power supplies
- to tune radio channels
- in memo



Parallel and Series



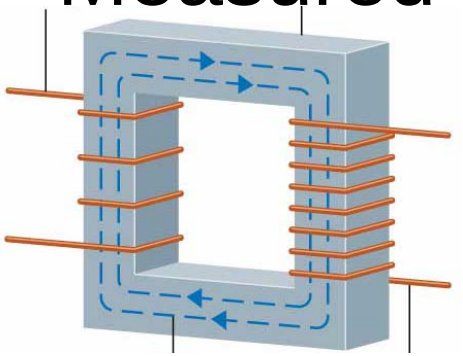
$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

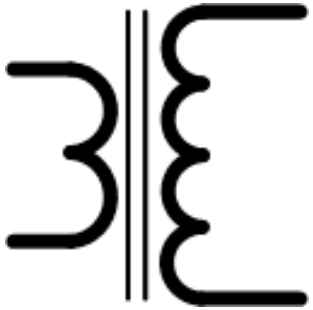


$$C_T = C_1 + C_2 + C_3$$

Inductors (Coils)

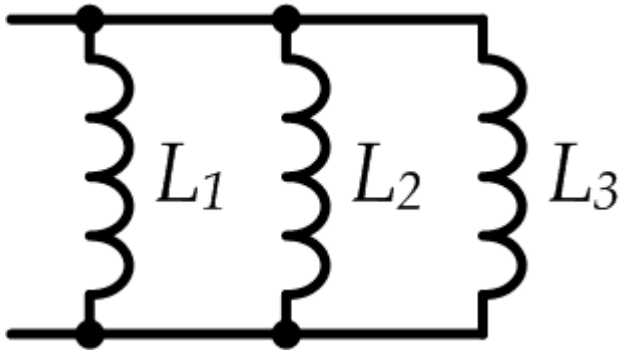
- A winding in a conductor line
- Resists (reacts) AC current with delay
  - no effect when DC is used
- Measured in Henry (H)





Parallel and Series

$$L_T = L_1 + L_2 + L_3$$



$$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}$$

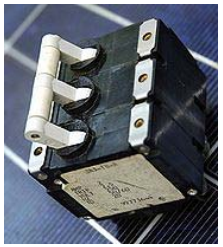
Fuses

- Protection devices
- Current limiting devices
- High current ➔ wire melts ➔ open circuit

Circuit Breaker

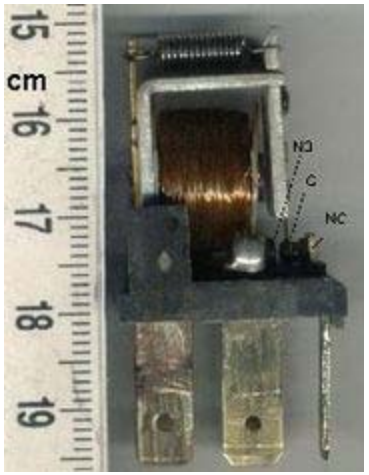
- Re-usable fuse or switch
- Current increases➔ Stronger Magnet ➔ open circuit
- Reset breaker ➔ current resumes
- Magnetic, Thermal, semiconductor breakers

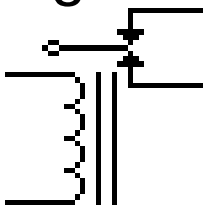
Circuit Symbols

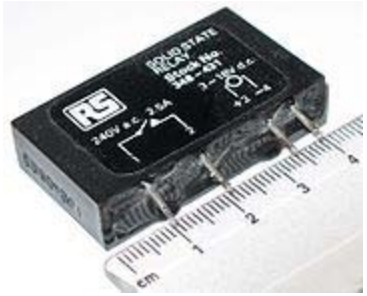


Relays

- Switch to change contact points
- Controlled via electric current
- Current in a coil ➔ Magnet ➔ Pull a metal lever ➔ change contact
- Can be used in turning lights or motors ON/OFF

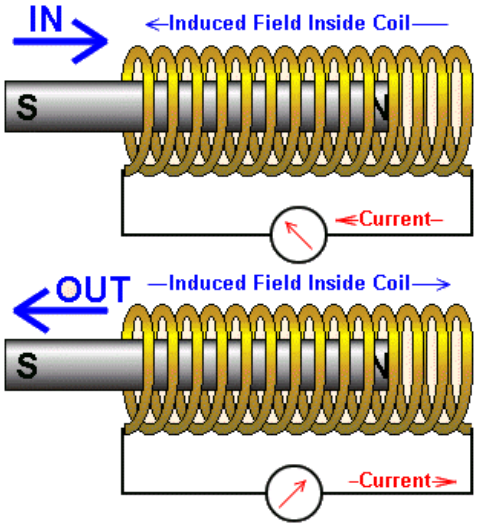






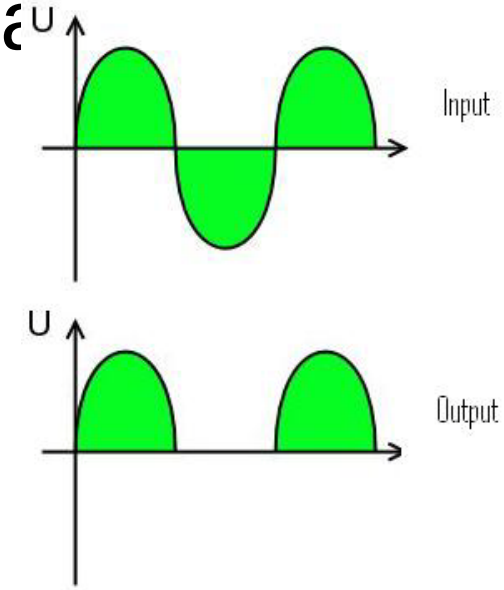
Solenoids

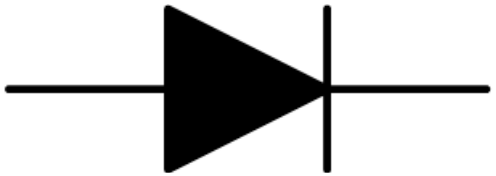
- Electrical energy ➔ Magnetic energy ➔ Linear motion
- Can be used for
  - Pushing buttons, hitting keys on a piano, valve operators, and even for jumping robots

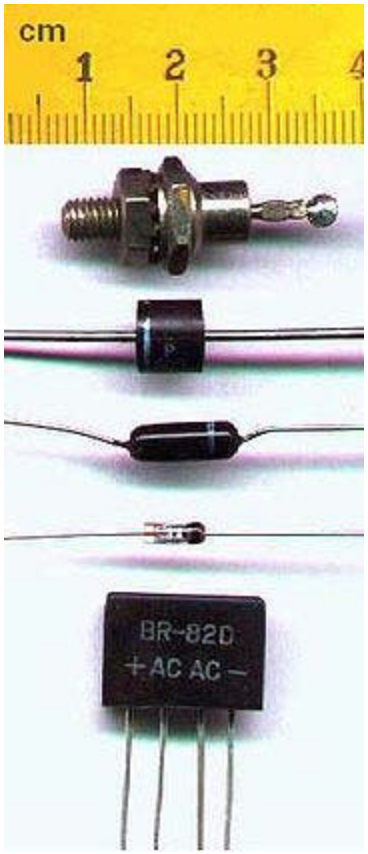


Diodes

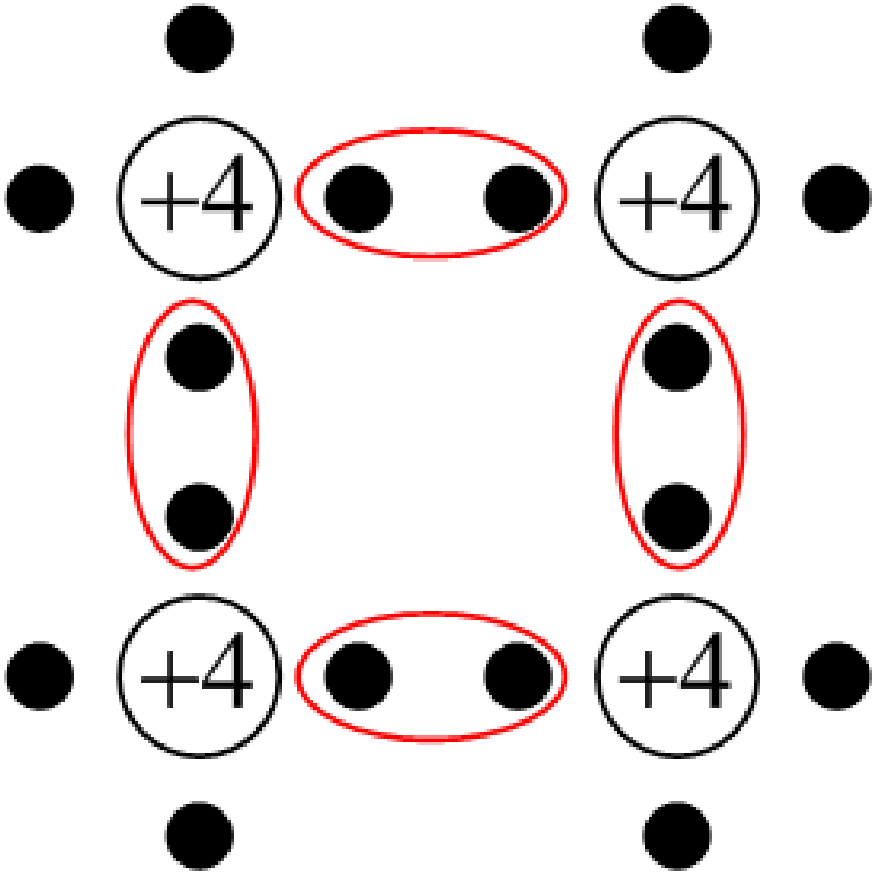
- Conducts current in one direction
- Many types with different



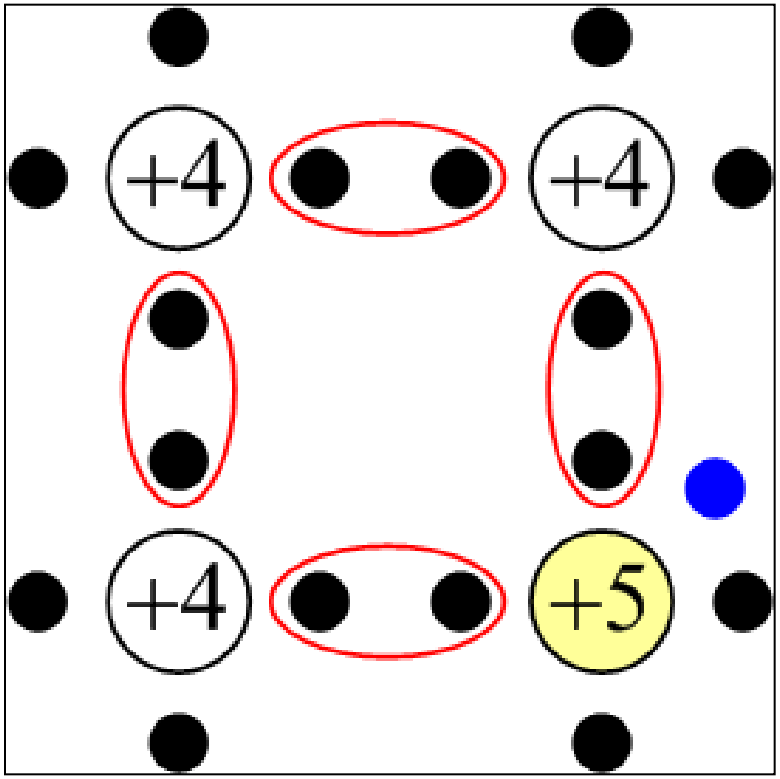




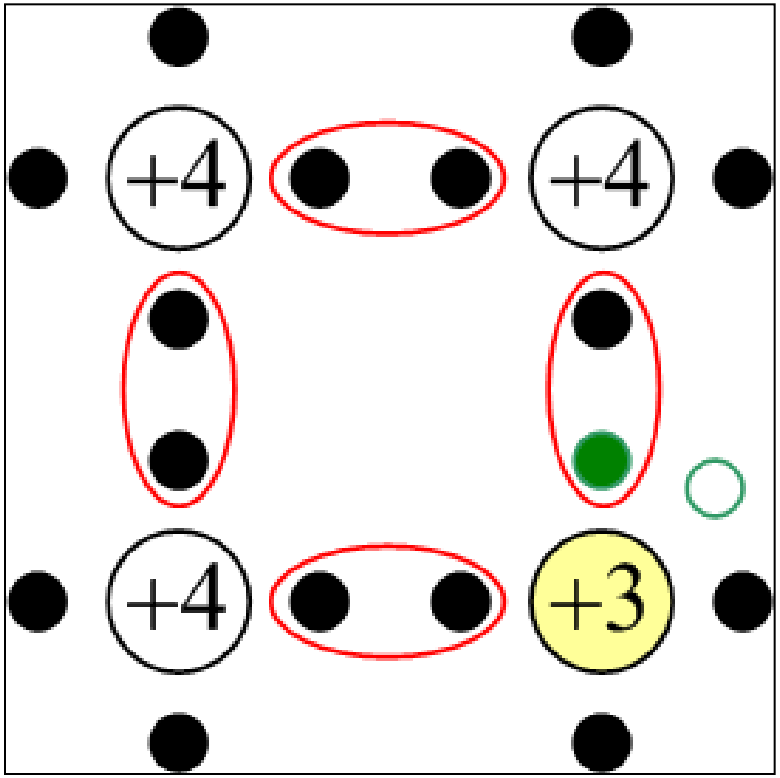
Silicon Crystal



Doping

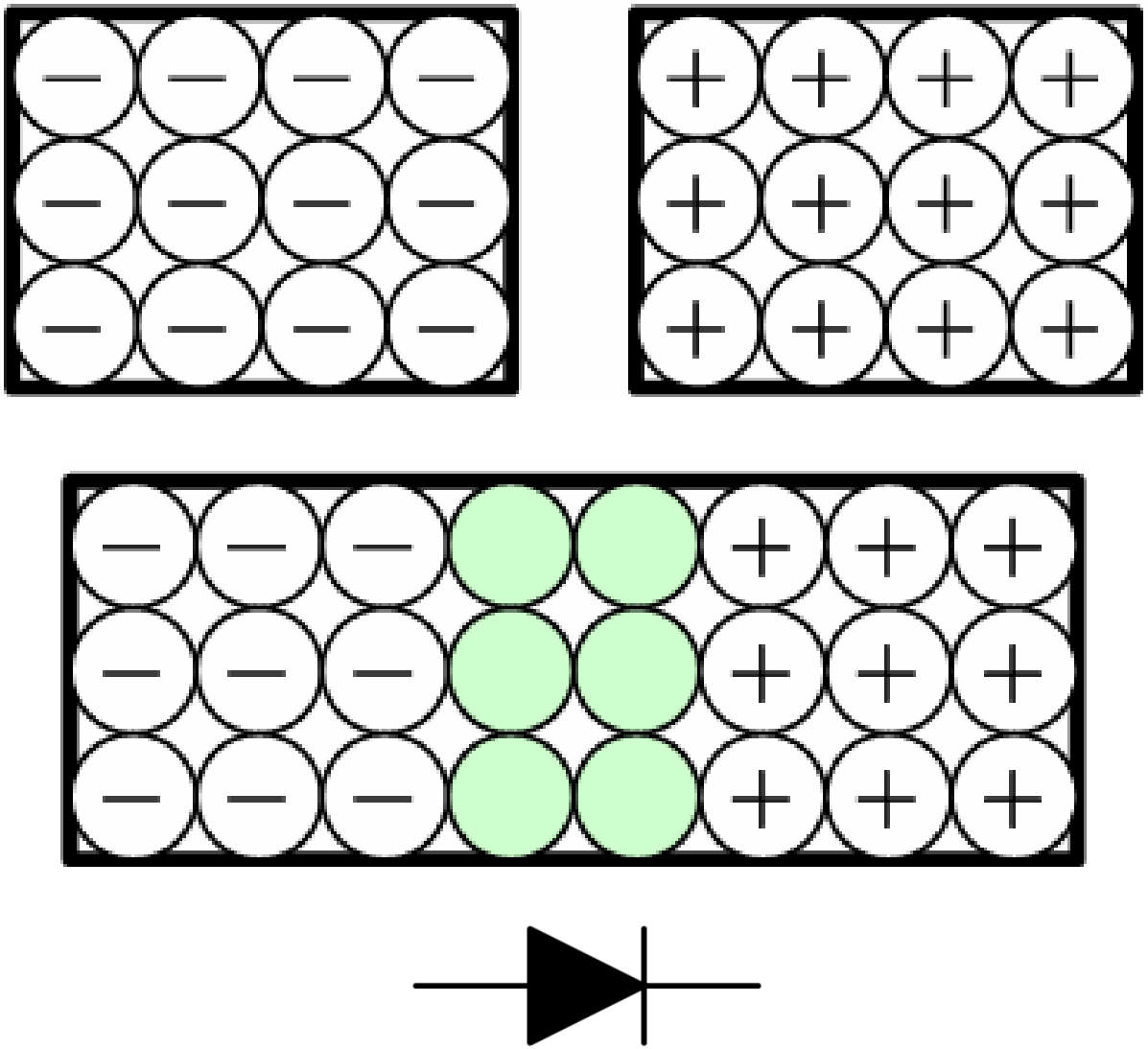


n-type

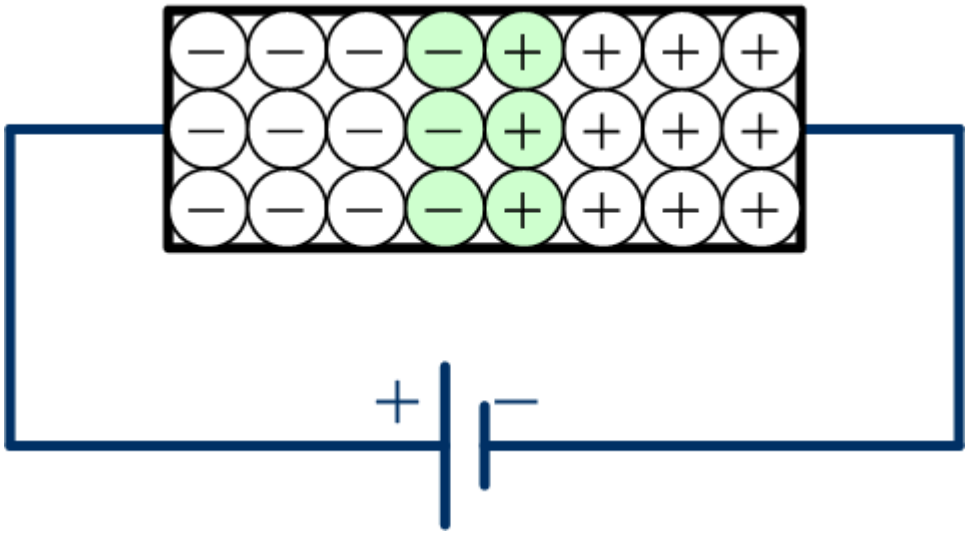


p-type

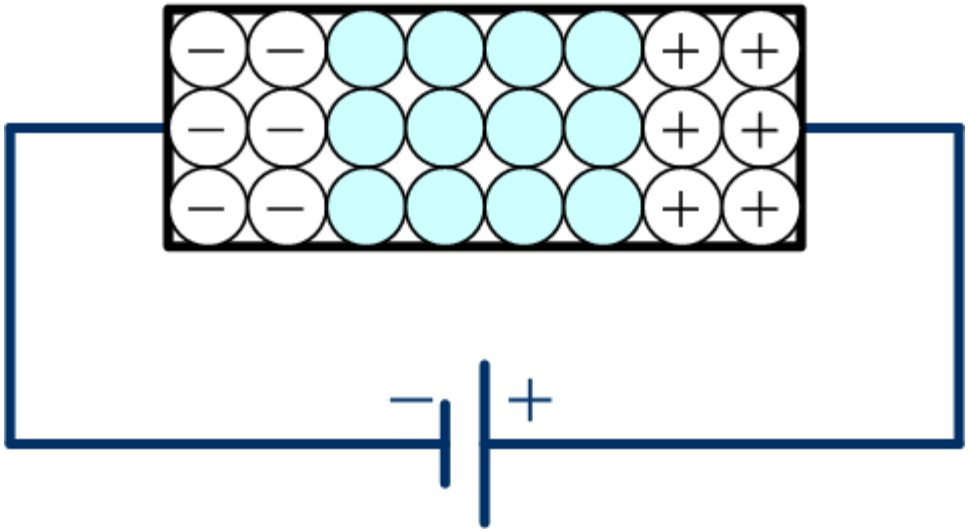
PN Junction



PN Junction



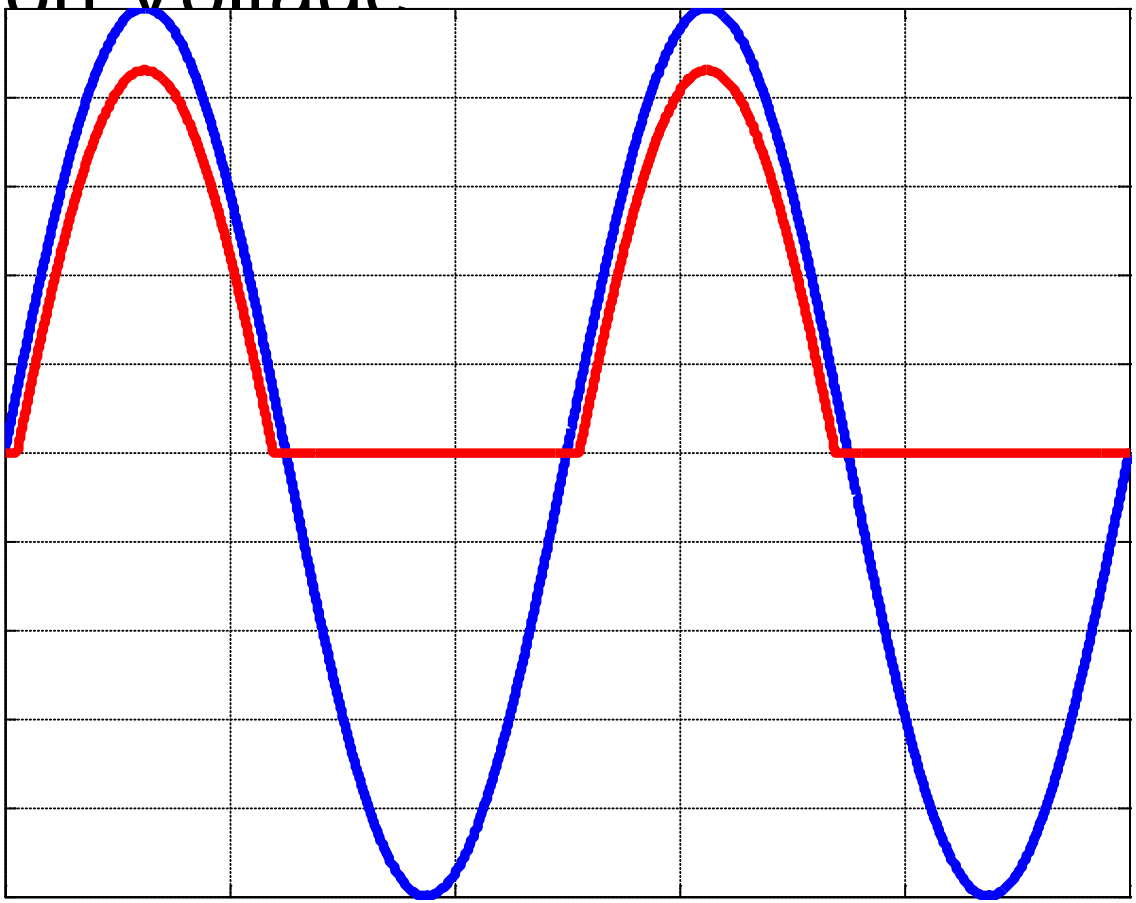
forward bias



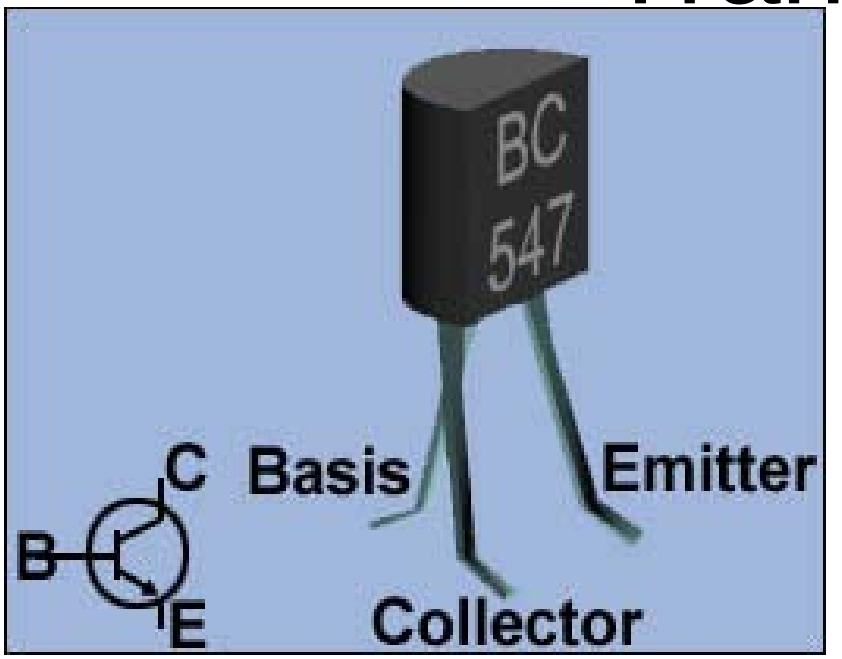
reverse bias

Diodes

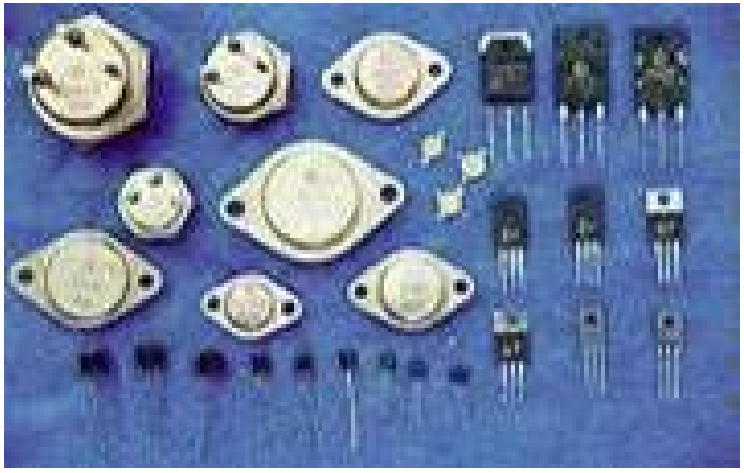
- Junction Voltage

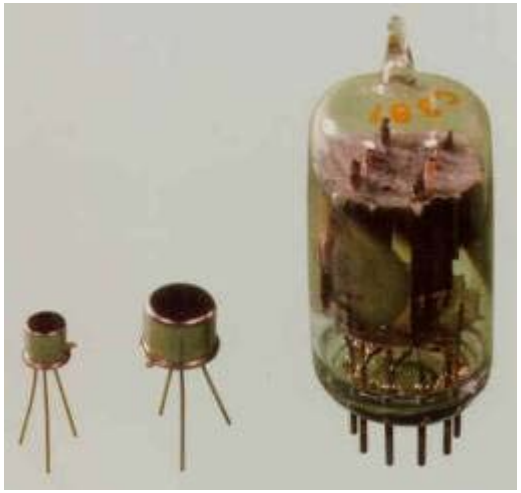


Trans

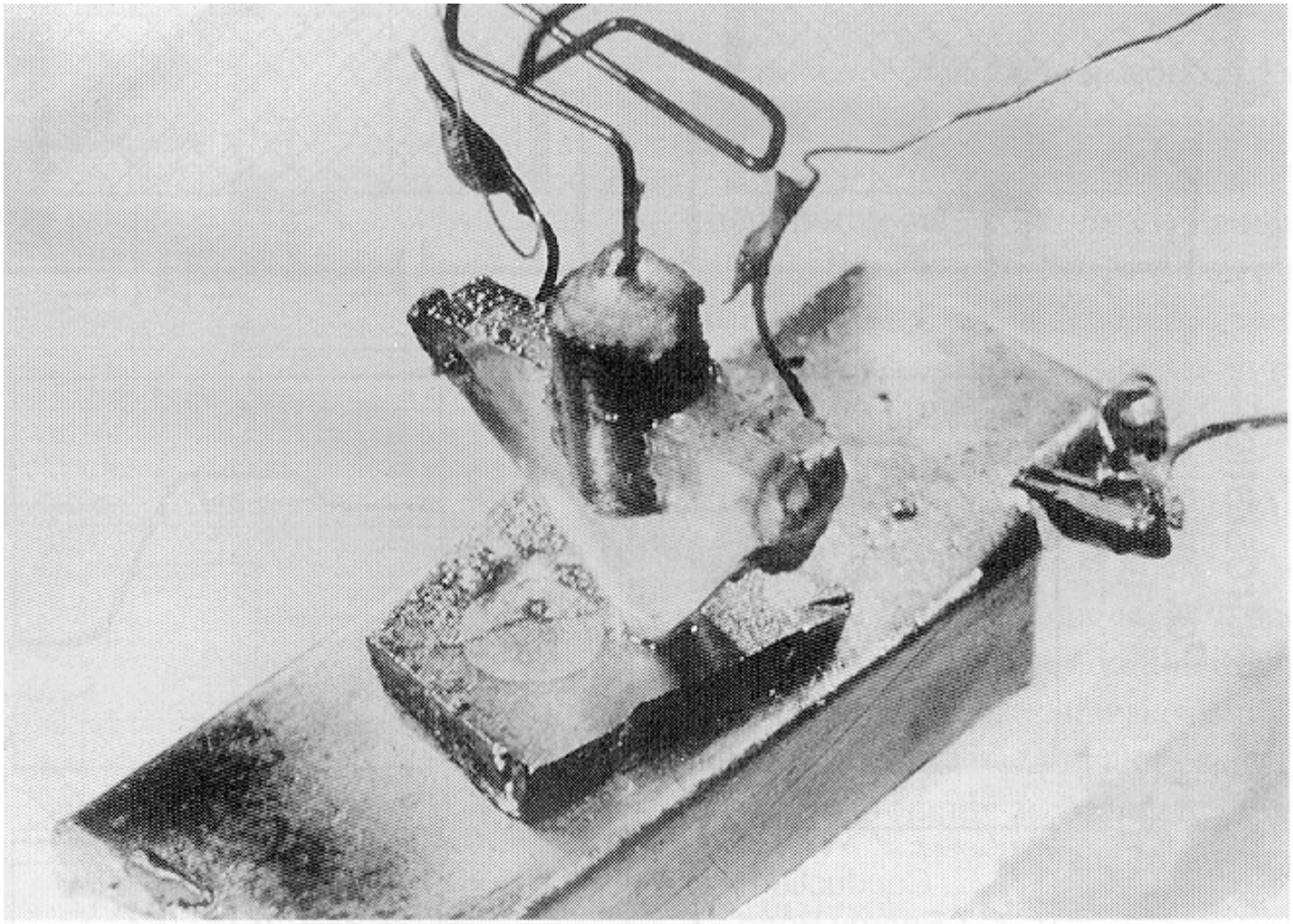

BC
547
C
Basis
Emitter
B
E
Collector


microelectronics group
A replica of the first transistor, invented at Bell Labs, December 23, 1947
Lucent Technologies
Bell Labs Innovations
50 Years and Counting...



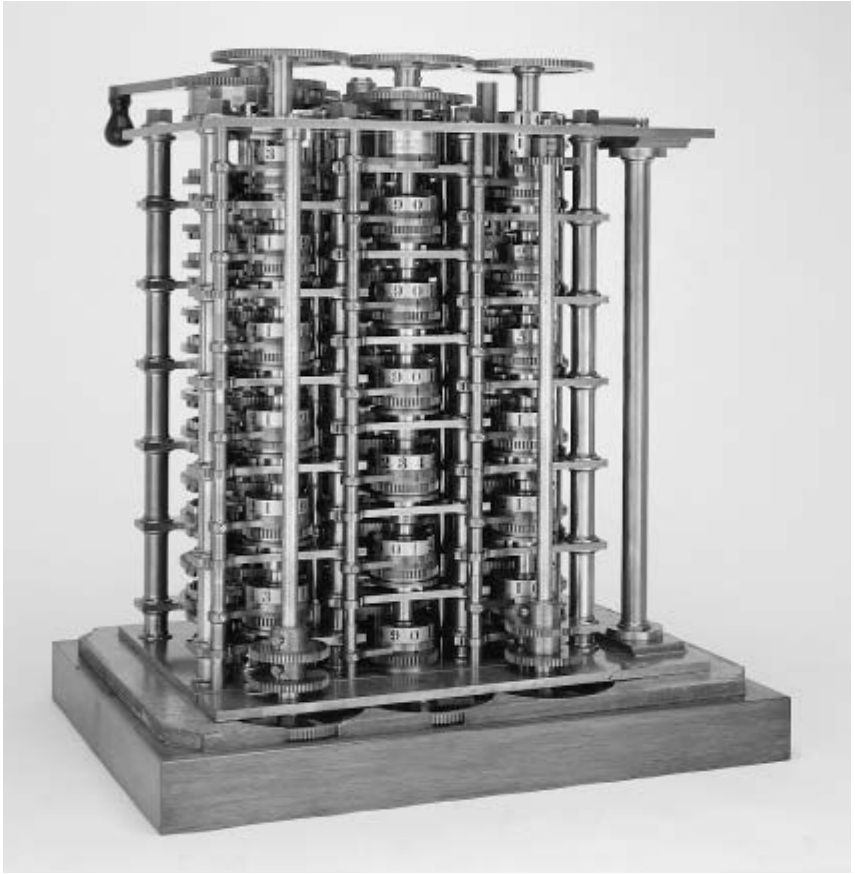


First Transistor (1948)



Digital Electronic Solutions

- why electronic?
- why digital?

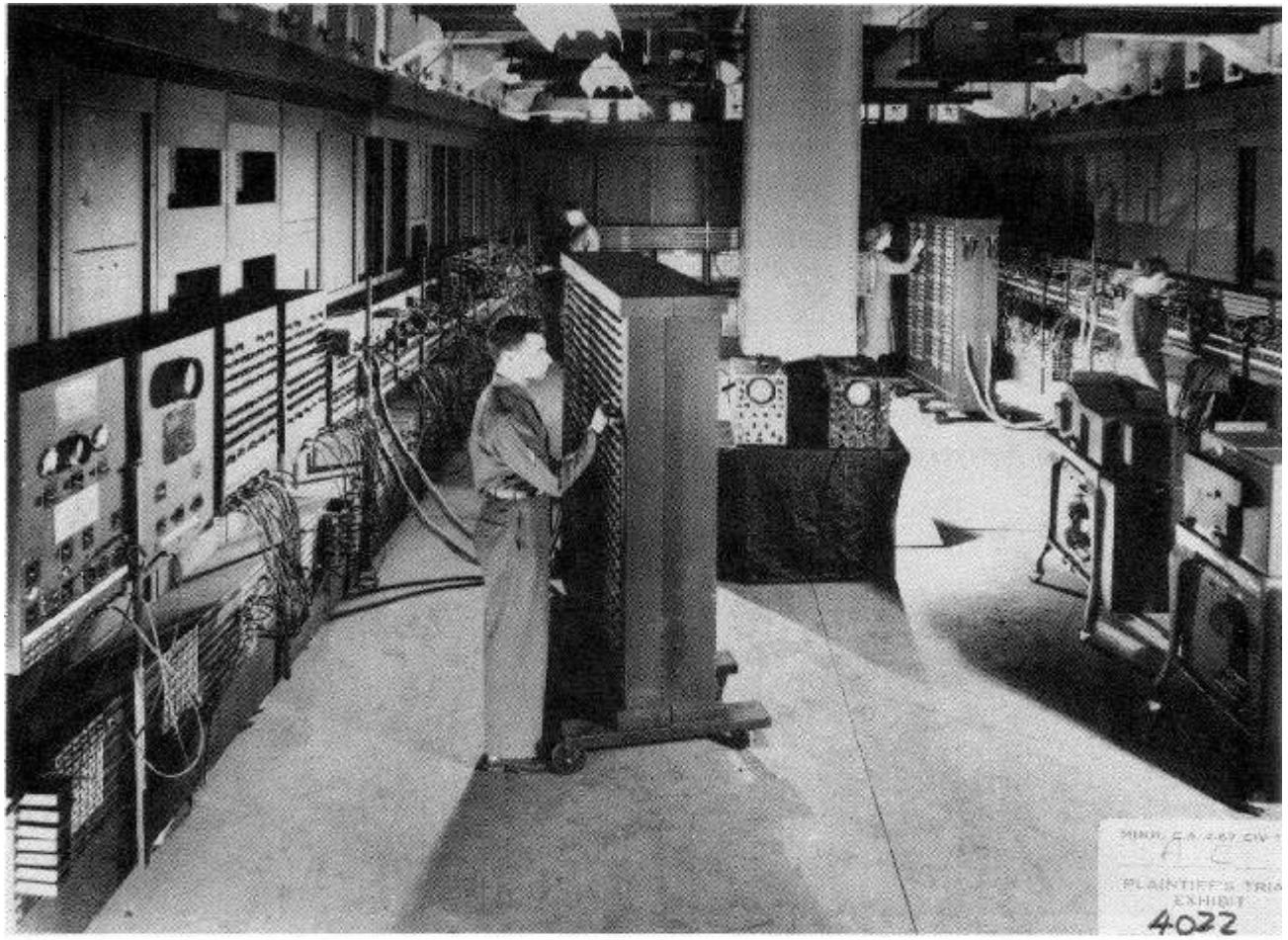


Difference Engine (1832)

25,000 parts
£17,470

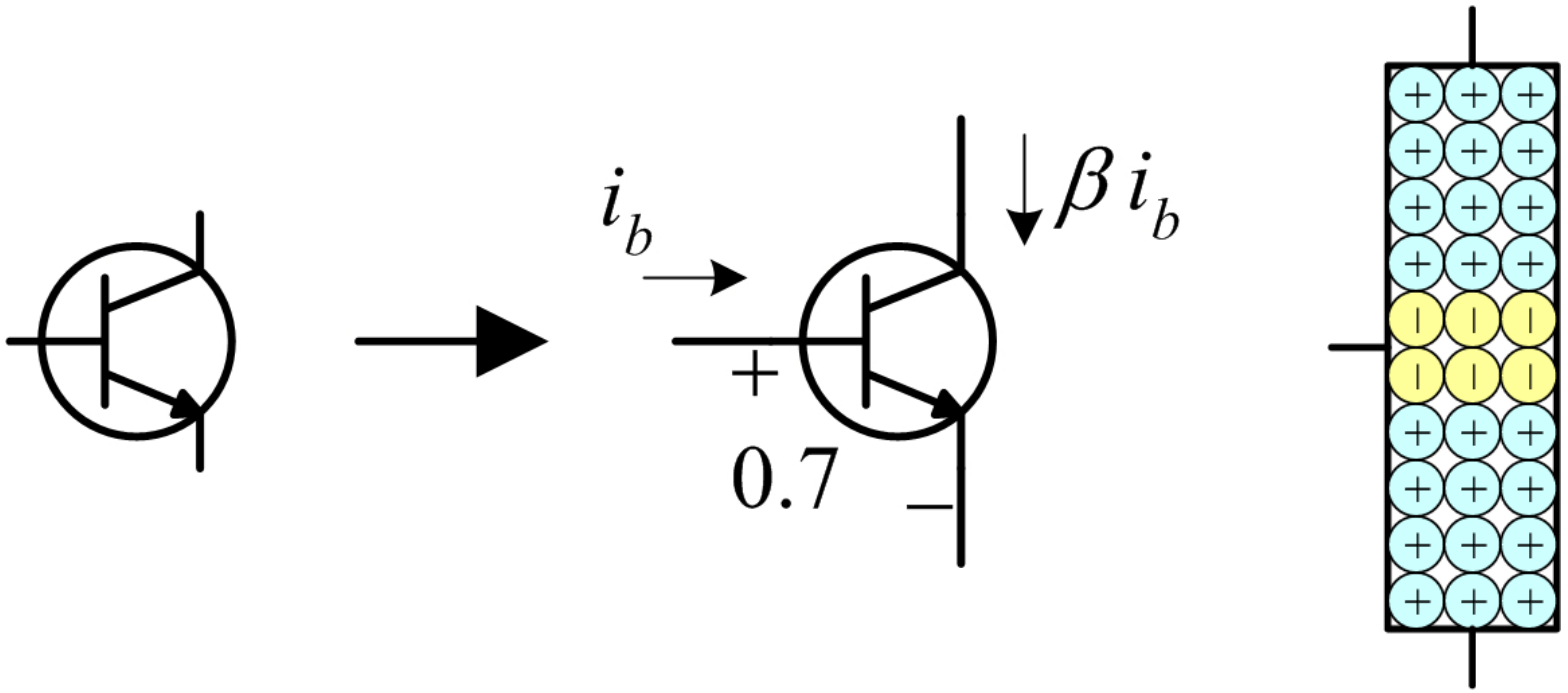
First Electronic Computer

ENIAC (1946)



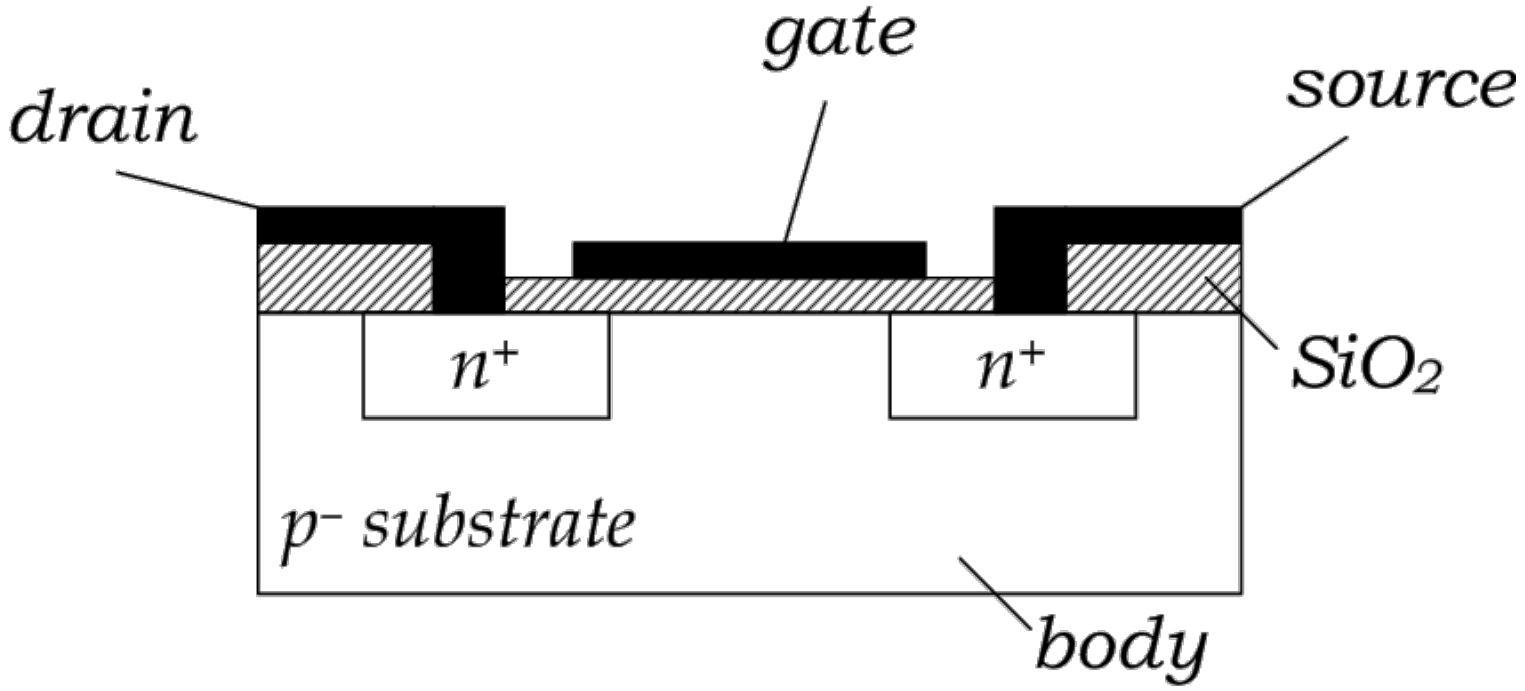
Bipolar Junction Transistor

- When biased correctly by DC source:
  - $I_C = \beta\, I_B$ $\qquad (30 \le \beta \le 400)$

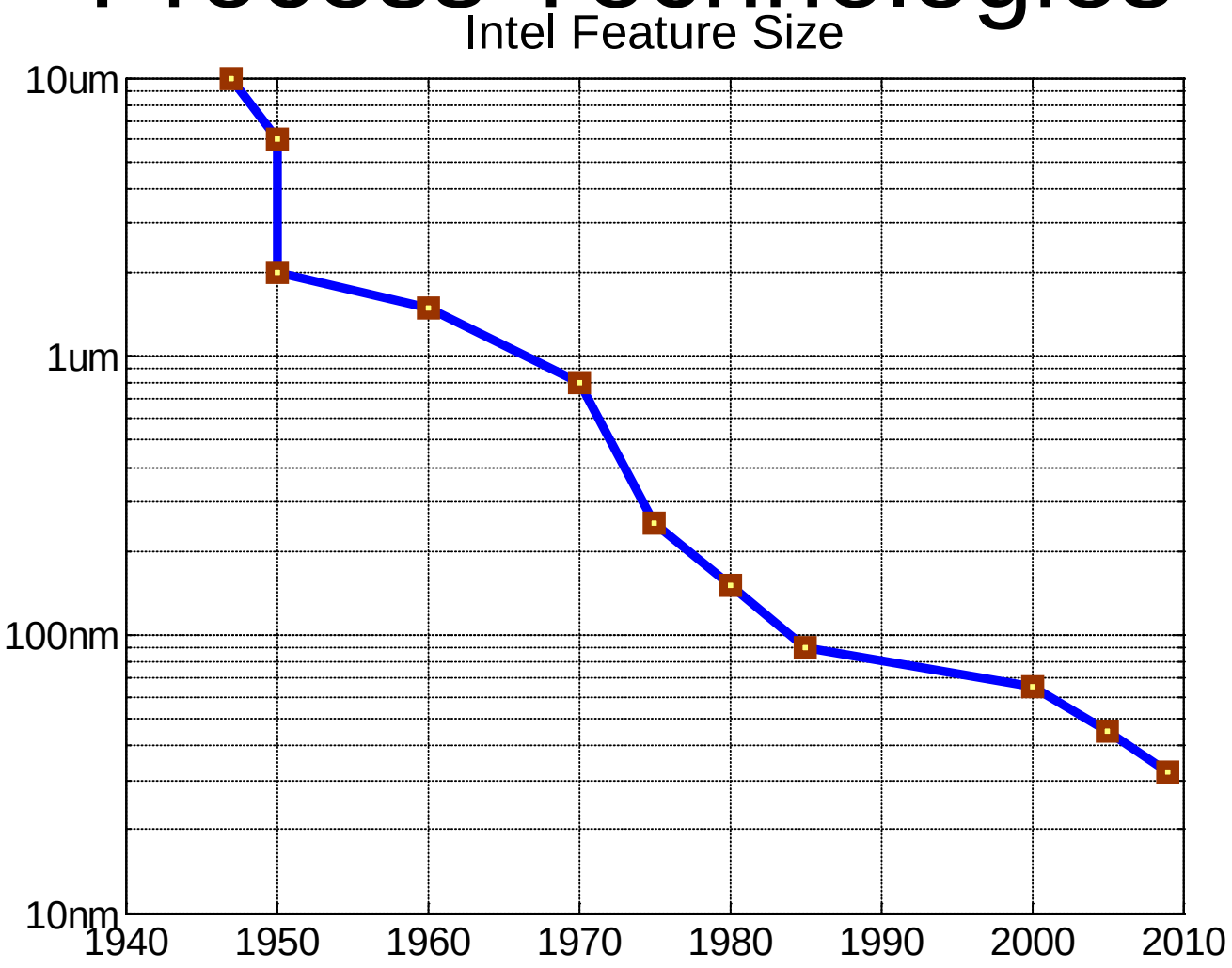


MOSFET

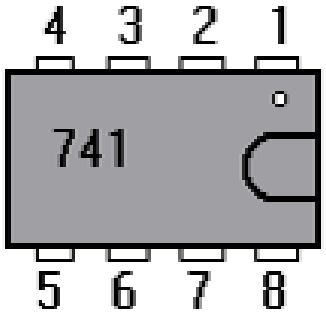
- MOSFET:
  - Metal Oxide Semiconductor Field Effect Transistor
  - A switch

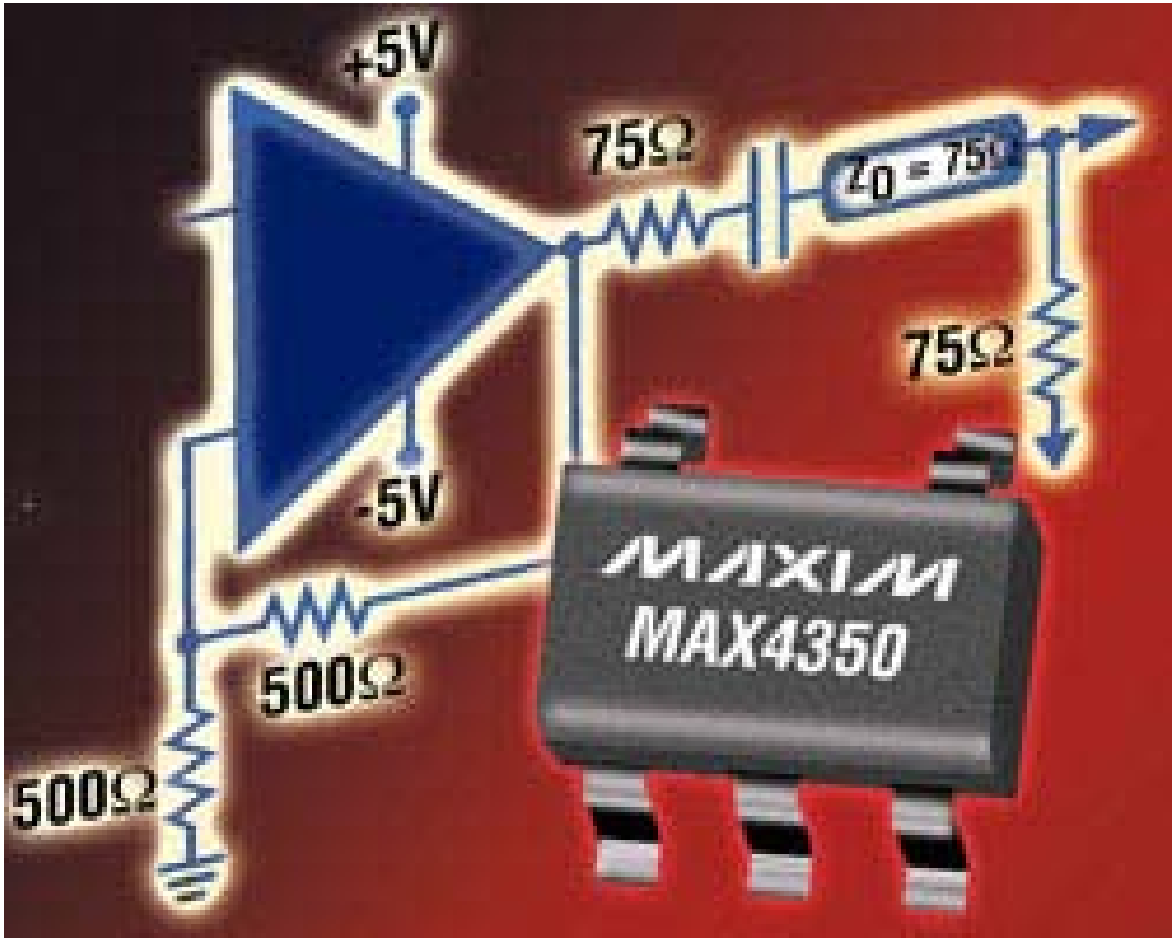


Process Technologies



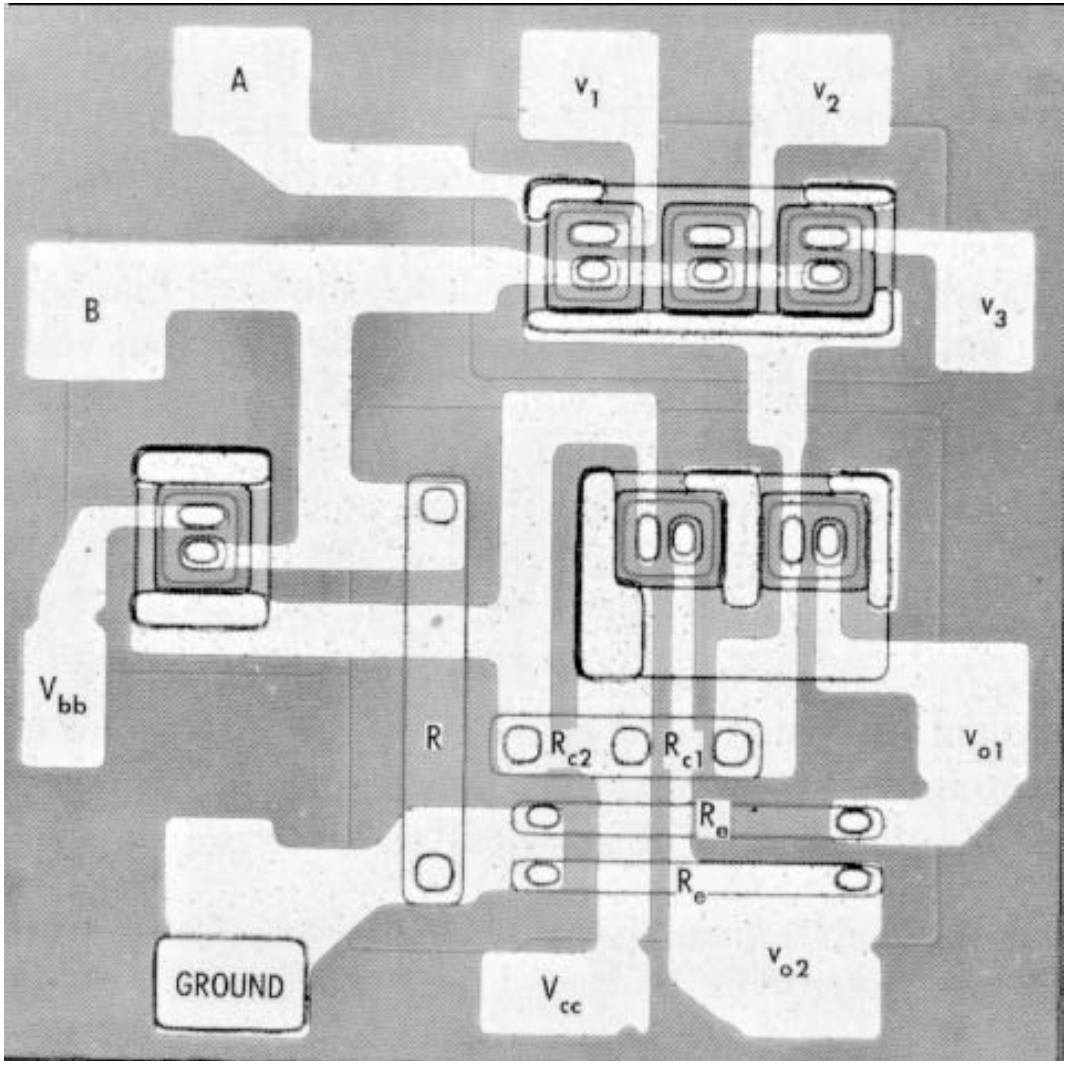
Integrated Circuits





First Integrated Circuit (1960)

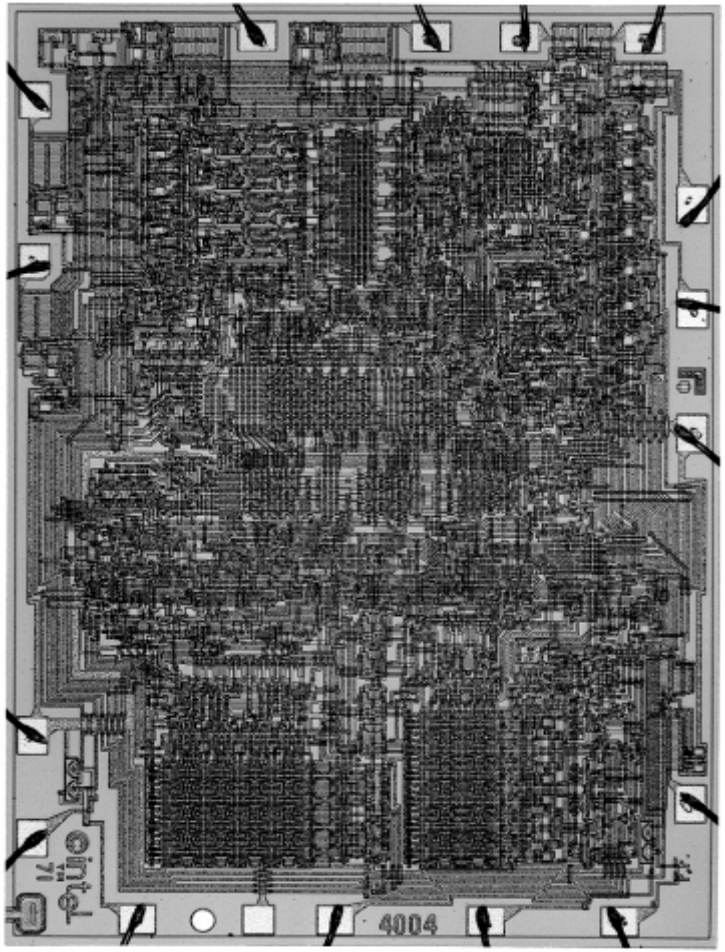
Bipolar Logic



Intel 4004 Processor

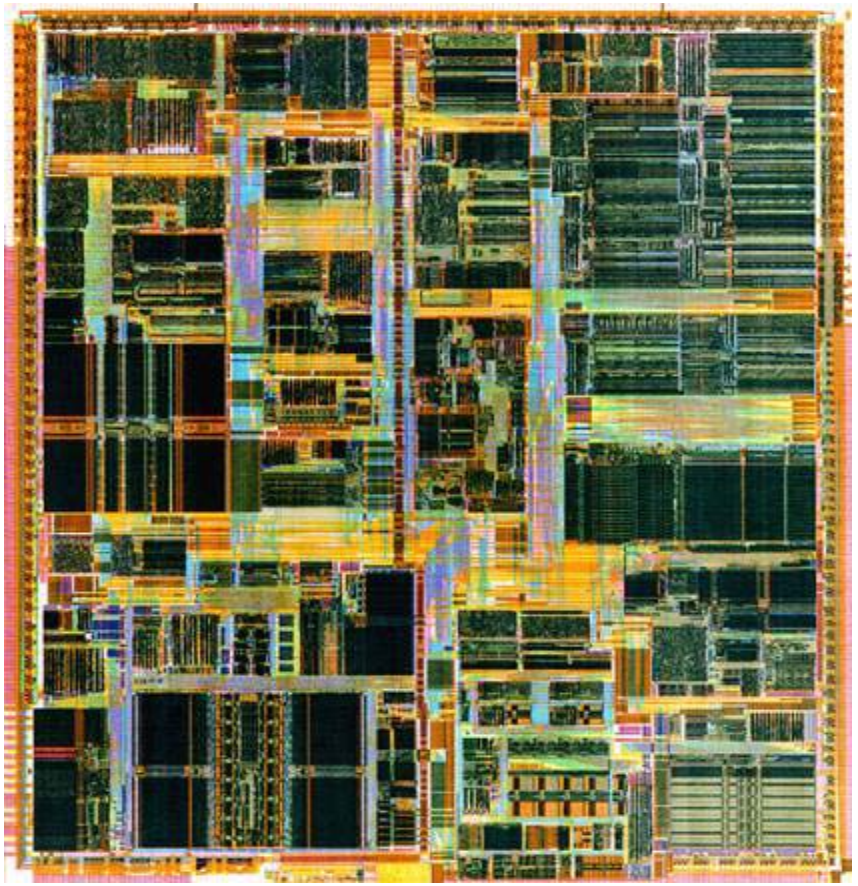
(1971)

1000 Transistor
1MHz



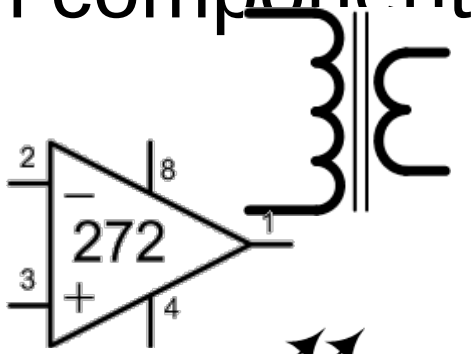
Pentium 4 Processor

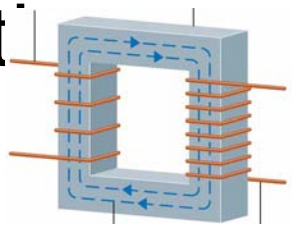
- P4 1994
- 1.7 GHz
- 0.91 cm^2
- 3.3M transistors
- 0.35 micron = 350nm
- 4 layers metal
- 3.3volt VDD

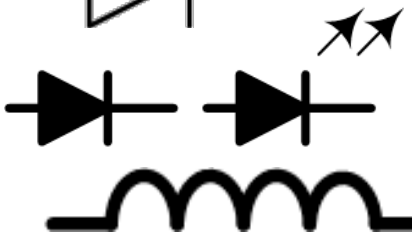


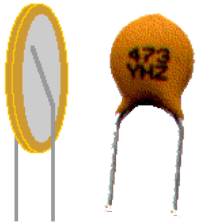
Other Components

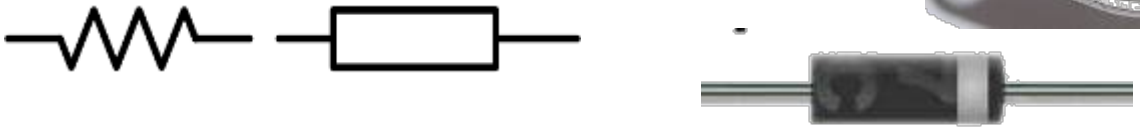
- Each component does a specific function
- Each component has a symbol in circuits
- Each component has specificat











Process Check

- So many components, so what?
  - What exactly do I need to know about electronic components?
  - Are there other important components I should know about?
  - Up to what level should a non-EE engineer get to know the details?