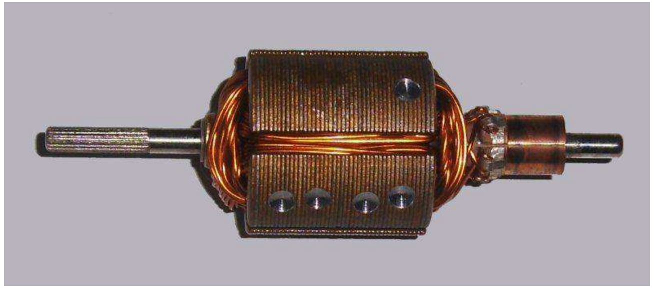
DC Motors Speed Control

Karen Xiong

Working Principle

When a current carrying conductor (the armature) is placed in a magnetic field, it experiences a mechanical force.

- When the conductor is supplied with current, it produces its own magnetic flux
- The accumulation of the magnetic flux exerts a force on the conductor and starts rotating



Armature

The speed of a DC motor can be controlled in three ways:

1. By varying the supply voltage

2. By varying the flux, and by varying the current through the field winding

3. By varying the armature voltage, and by varying the armature resistance

Speed of a DC Motor

$$V = E_b + I_a R_a$$

$V \rightarrow$ supplied voltage, $I_a \rightarrow$ armature current, $R_a \rightarrow$ armature resistance

$E_b = (P\phi NZ)/(60A) \rightarrow$ back EMF

$P \rightarrow$ number of poles

$A \rightarrow$ constant

$Z \rightarrow$ number of conductors

$N \rightarrow$ speed of motor

Rearranging the equation

$N \propto KE_b/\emptyset$ where K is a constant

Therefore the speed of the motor is:

- inversely proportional to the flux per pole
- directly proportional to the back emf

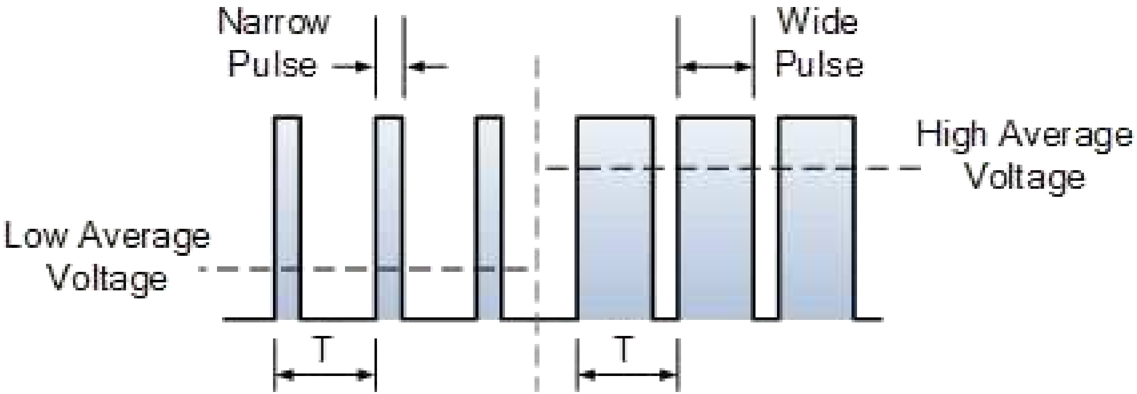
Voltage Control Method

PWM

The power applied to the motor can be controlled by varying the width of the applied voltages

The wider the pulse width, the more average voltage applied to the motor terminals

The longer the pulse is high, the faster the motor will rotate

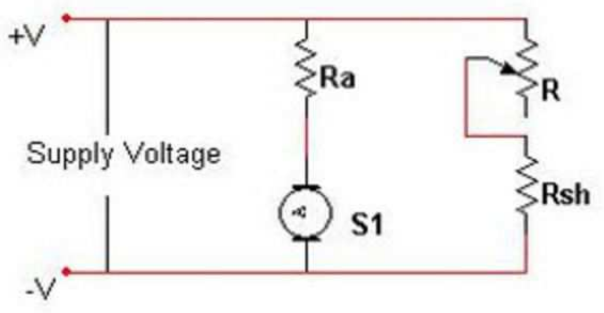


Flux Control Method

Achieved by using a variable resistor (potentiometer) in series with the field winding resistor

When the variable resistor is kept at its minimum position, the rated current flows through the field winding due to a rated supply voltage

When the resistance is increased, the current through the field winding decreases and in turn decreases the flux produced



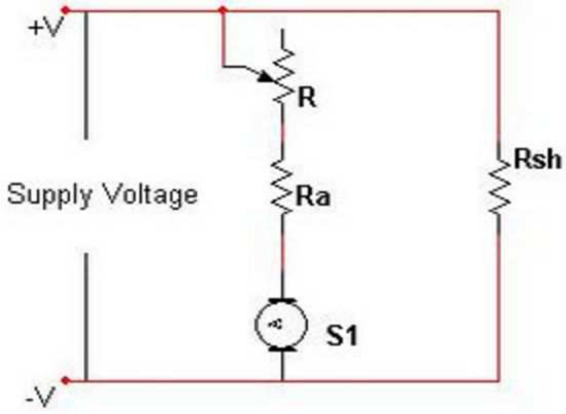
Flux Control method

Armature Control Method

When V and R_a are kept constant, speed is directly proportional to the armature current

If we add a resistance in series with the armature, I_a decreases and so does the speed

The greater the resistance, the greater the decrease in speed



Armature Control method

References

http://www.electronics-tutorials.ws/blog/pulse-width-modulation.html

https://www.elprocus.com/what-are-the-best-ways-to-control-the-speed-of-dc-motor/

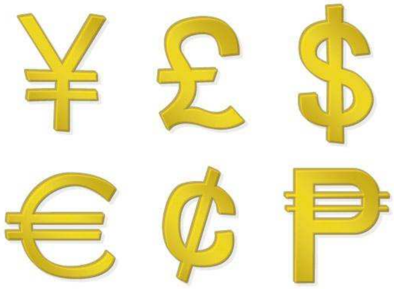
http://www.electricaleasy.com/2014/01/speed-control-methods-of-dc-motor.html

Display Technologies

Thomas Deeds

Important Considerations for Embedded Systems

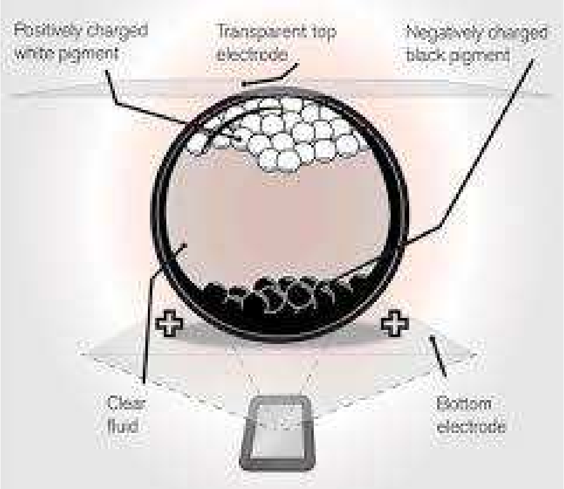
- Power consumption
- Thinness
- Color vs. Black/White
- Availability
- Cost



Sources: iconsdb.com, deluxevectors.com

E-Ink / E-Paper

- Each pixel is an ink-filled capsule
  - Positively (+) charged white ink
  - Negatively (-) charged black ink
- Electrode voltage controls which color is visible



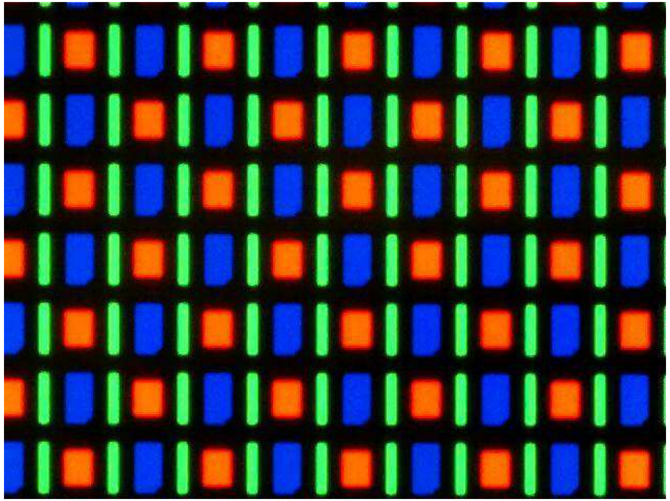
Source: e-ink.com

E-Ink / E-Paper

- Advantages
  - Low/No power consumption when image is static
  - Flexible versions exists
- Disadvantages
  - Limited to 3 colors max
  - Slow refresh rate (this is flexible)

OLED / AMOLED

- Each pixel consists of 3 OLEDs (Red, Green, Blue)
- Brightness of each OLED determines brightness/color of pixel



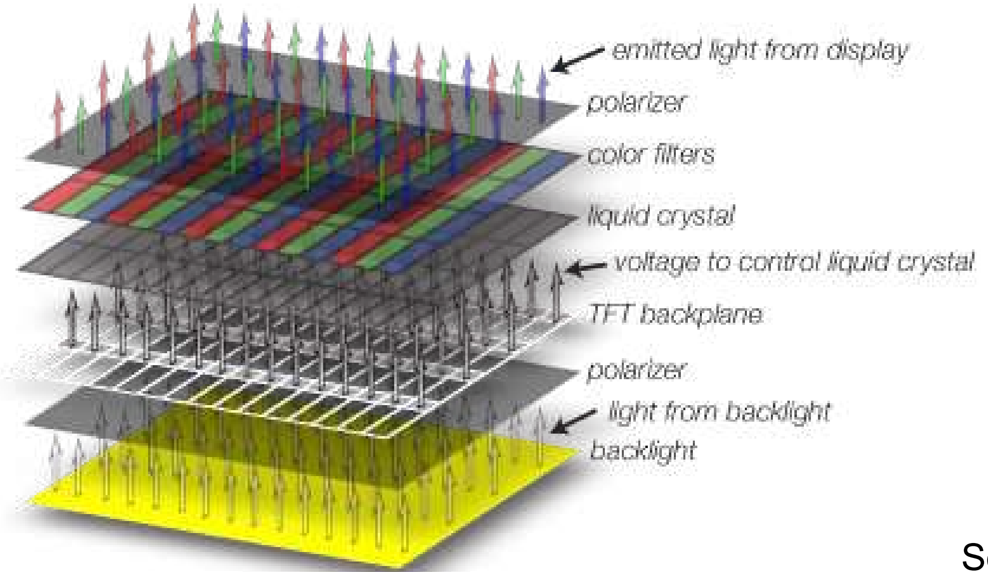
Source: wikipedia.org

OLED / AMOLED

- Advantages
  - Very thin
  - Low power consumption
  - Flexible versions exist
- Disadvantages
  - Inconsistent power use
  - More expensive

LCD

- Liquid crystal layer
- Transparency changes when voltage applied
- Controls how much backlight shines through each pixel (and sub-pixel)



Source: Amoledtv.com

LCD

- Advantages
  - Widely available
  - Consistent power use (because backlight is always fully on)
- Disadvantages:

New Cool Technology

- Flexible Displays (OLED and E-ink)

Sources: slashgear.com and androidauthority.com

Semiconductors (P & N Type)

By: Aziz Fall

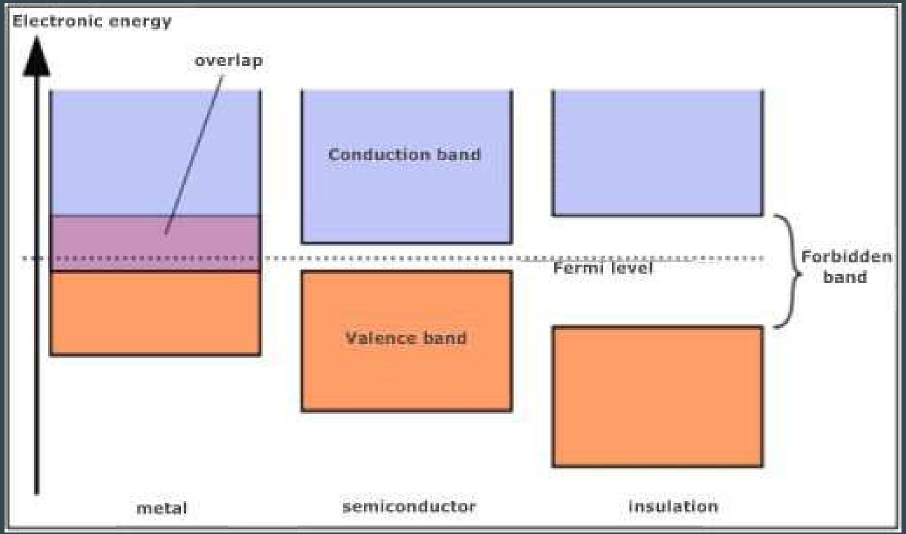
Electrons (Fermi Energy)

- Electrons are fermions and they obey fermi-statistics. Thus for an electron in a potential, it must be occupied in pairs of each principal quantum number in each quantized energy level.
- The electron at the top most level has a non zero energy at T = 0 called Ef (Fermi energy)
- When you apply an Electric field the net effect is shifting electrons near the fermi level
- The electron is effectively a wave and the mean free path is dependent on deviations from a perfect lattice not classical collisions with atoms. (Thus impurities can affect electron conduction)

BAND THEORY OF SOLIDS (Kronig-Penney Model)

-Electrons in a lattice can be modeled by a periodic square potential
- When you solve for schrodinger equations you see that there are periodic gaps in values of k (wave number)
- Periodic gaps in k are known as band gaps

- Notice slight increases in temperature can increase the conduction of the semiconductors



Impurity in Semiconductors (N Type)

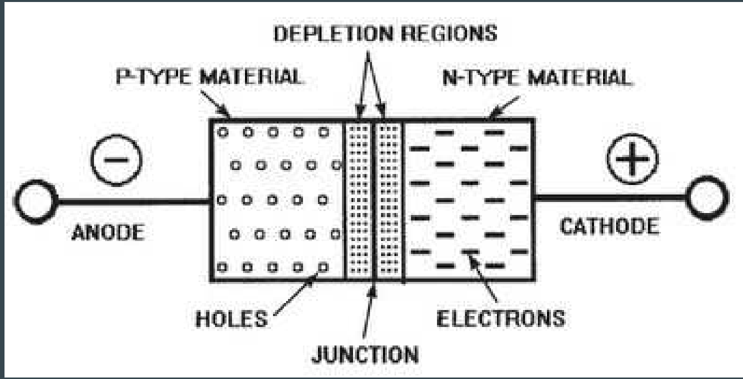
- Silicon is a typical semiconductor with 4 valence electrons, Arsenic with 5 valence electrons can replace a few of the atoms in the lattice such that 5 th electron in arsenic occupies an energy level just below the conduction band
- Ionization energy is comparable to kT at room temperature
- This is an N type Semiconductor

Impurity in Semiconductor (P Type)

- Same logic as N type but Silicon atom replaced by atom which has less valence electrons
- Creates virtual particles called electron holes, which are effectively positively charged

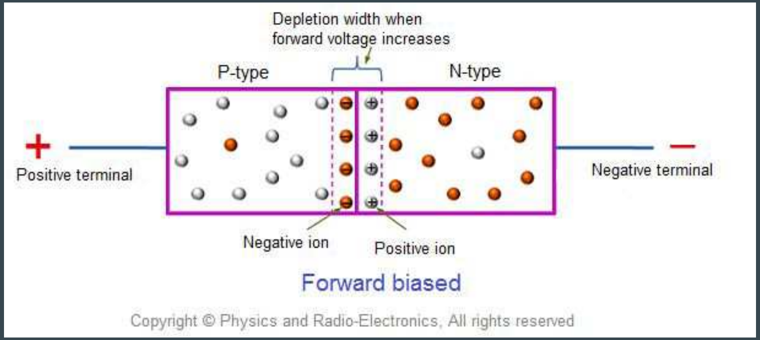
PN Junction

- Structure formed by neighboring P and N type semiconductor
- Holes from P diffuse into N region, and electrons from the N region diffuse into P region
- This creates a region depleted of charged particles this creates an electric field towards anode in depletion zone

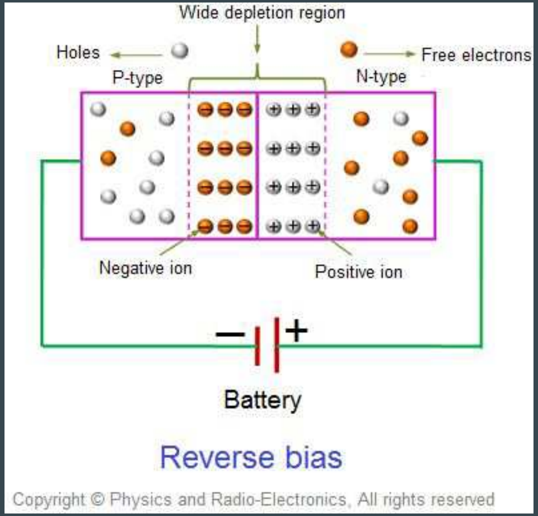


Forward and Reverse bias

Forward Bias



Reverse Bias



LEDS AND PHOTO-DIODE

-LED emit light through recombination, electron annihilates a hole, then emits light since it will in a state of lower energy

-Photo-diodes creates current through generation, a photon creates a hole pair which in return causes a current to flow.