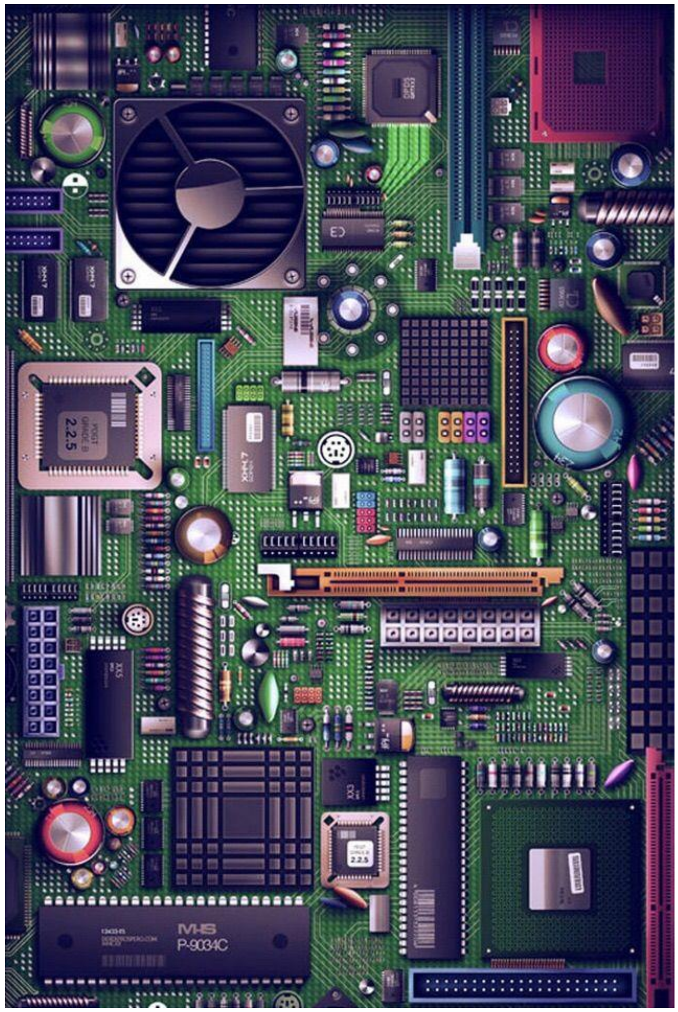


Report: Basic electrical components

R, L, C, DIODE & TRANSISITORS

SIDHARTH SEELA |E-POWERTRAIN TASKPHASE | 9TH AUGUST 2020

Resistor:

Resistor is device which resists the movement of current, which causes a potential drop. The amount of potential drop multiplied by the current flown through gives the power consumed by the resistor for resisting the flow of current. Due to the resistance to the flow of current, the resistor heats up and the heat (V*I*t) is expelled. It works on the principle of Ohm's law, which states V proportional to I.

- The resistance R is given as ratio of roe (intrinsic resistivity) and length by cross-sectional area. R = roe *L/A ohm
- Two types of resistance 1. linear resistance, and 2.non-linear.
- Linear resistors include nichrome, carbon composition. These resistors have a linear relationship between voltage and current and are bidirectional in nature.
- Non-Linear resistors include diodes, transistors basically semiconductors. These are unidirectional and hence in forward bias tend to have less resistance and when reverse biased tend to give high resistance. Also have regions where it becomes highly conductive and burns up due to heat energy.
- The effects of temperature affect the resistance. Using the expression of thermal expansion L' = L*(1 + alpha*delT) and keeping volume constant, the expansion in length causes decrease in cross-sectional area. The resistance increases with increase in temperature for linear resistors
- For non-linear resistors, the effect of temperature is proportional to number of charge carriers. Hence current increases for increase in temperature. Ex- In PN diode I_{o2} =I_{o1} *2^((T2-T1) /10)
- The resistance of a particular resistor can be decreased by using multiple of them in parallel so that their equivalent resistance becomes r' = r/n
- The resistance of a particular resistor can be increased conversely by putting them in series so that r' = r*n

Capacitor:

When we have two conductive plates put apart with some distance and then given some potential difference causes it to accumulate opposite charges on the said plates. The no of charges held are directly proportional to the dielectric constant (relative permittivity) of the medium in between and cross-sectional area of the plate and inversely proportional to distance between the plates. C= e_r *A/d.

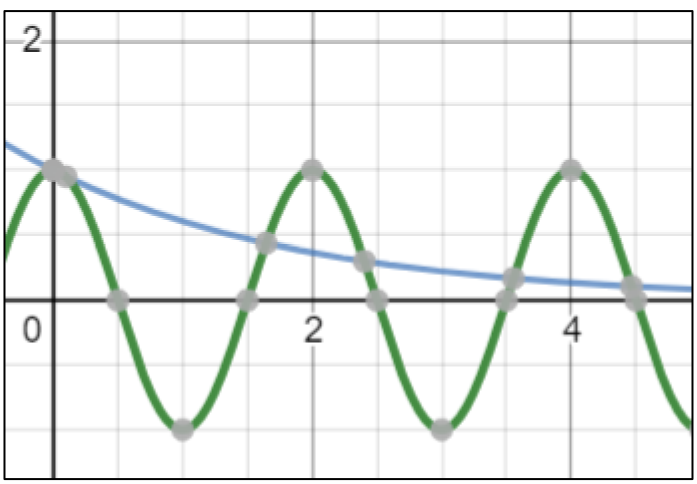
- E_r is the relative permittivity (tells us about the dielectrics polarizability), A(the amount of charge able to be spread in the area),d (as the distance increases the field decreases due to dv/dr)
- The charge held by it is proportional to capacitance (charge bearing capacity) and voltage (the supply of field).
- It acts as an infinite resistor till some heavy field is put known as its dielectric strength after which it conducts and breaks down. Ex – Lightning.
- Because it acts as an open circuit when it gets charged. It is used in ac circuits to help smoothen output signals due to its fixed discharge rate.
- The ½ time period of ac signals is always chosen to be less than the time it takes to charge the capacitor or else the current wont flow leading to current losses. As the voltage is shared between the two plates the average voltage becomes v/2 and hence the energy stored is qv/2.
- There are two types of capacitors, polar capacitors and non-polar (bidirectional). Polar ex – al electrolytic capacitor (uses aluminum oxide as dielectric medium) and non-polar ex- mica-based capacitor.
- Always the current that flows through the capacitor is the displacement current (current caused due to changing electric flux inside the dielectric).
- 

Fig 1. Keeping time period 2 seconds. We can see discharge of capacitor from 0 to before 2 and the charging from that point to 2. This signal from 0 to 2 keeps on repeating when capacitor is used as filter. (Desmos)

Inductor:

An inductor is device which has an insulated wire (to reduce eddy currents) wound to make a toroid or solenoid. To make it more efficient and stronger its wound around a magnetic metal core.

- It works on the concept that when there is some current, it produces a magnetic field through the core proportional to the current and number of windings.

- When another inductor in placed on the axis relative to each other, there is formation of magnetic induction linkage. As the magnetic flux is the same inside both the inductors and there is an inductor linkage (phi_b proportional I) hence the current in L1 causes a current in L2 by mutual inductance, the number of windings relative causes one to have more amplitude than another. But power remains conserved (v increases, I decreases to compensate for same P) in reality there are power losses due to self-inductance, eddy current, flux leakage. Ex- used in transformer.

- There is another property of inductors, self-inductance, whenever there is changes in current in coil it causes change in magnetic flux causing it too produce a reverse emf (eddy law). This property is used in RLC circuits to filter signals.

- The energy is stored as magnetic energy ½*Li^2.

- In ac, the voltage leads in inductor because at t=0 when switch is on applied v is V (0 to v, +v) and self-induced v is -V which causes zero current. But when switch is turned off at t = T the applied v = 0 (+v to 0) but self -induced v is +V which causes the same previous current. As we can see the odd even relationship. If we make this more continuous like sinusoidal and co-sinusoidal then we can see there would be a lead of voltage.

Diode:

Semi-conductors are conductors which have silicon or germanium cores. These conduct with temperature, as the temperature increases the more the energy received to excite the electrons from ground state to excited state. But when doping (introduction of impurities of 5 or 3 valence atoms) there leads to a creation of more holes or electrons than the semiconductor could have provided purely. In n-type there are 5 electron valence atoms and hence it exists a positive ion and electron on the excited state. In p-type there are 3 electron valence atoms and hence it takes an electron to the ground and keeps a hole left by it on conduction region.

When a p type semiconductor is doped with n-type dopant on one end, it becomes a p-n junction. It forms a thin depletion layer between the junction without any biasing. The layer is depleted of any charge carriers and has only minority charge carriers flowing through them because of the voltage difference (barrier potential) aiding their flow to majority regions.

There are three regions where the diode's characteristics are observed-

- Forward bias- when higher potential is applied on p end and vice-versa on n end. The barrier potential reduces to 0 as the voltage is increased due to barrier width becoming 0. The electrons push into the positive ions and holes push into negative ions. And it works like a 2 joined semiconductors. V_B =0.7 (silicon), 0.3 (germanium).

- No bias – there is a small barrier created known as barrier junction potential.

- Reverse bias -the barrier enlarges devoid of more charge carriers makes its barrier potential larger but as the voltage applied becomes more negative the minority current increases in tiny increments. And after a certain breakdown voltage it gets destroyed due to infinite change in current.

Transistor:

When an n-based is doped with p impurity at both sides of the chip, a BJT is formed. When a silicon oxide chip has metal contact on one side and a p-substrate on the other end with n type doping on p-substrates ends, a MOSFET is formed. The function of a transistor is to act like a switch, amplifier, square wave generator, comparator.

MOSFET-

- It acts like a capacitor when connected to gate and bias. It is bidirectional. Source and gate are indistinguishable.

- When a voltage is applied across gate and p-substrate is applied it causes the silicon oxide to ionize and create opposite charges on contacts. So now the p-substrate has acquired a bank of electrons due to the field, created by the capacitor like properties, so now the number of electrons accumulated in the channel is controlled by gate voltage and drain voltage. The difference in gate and drain voltage is to be sufficiently positive ($>V_{TH}$) that the decrease in potential across the channel is compensated for.

- The channel acts as a resistor of potential drop equivalent to gate voltage.

- The electrons are provided by the free electrons in p-type substrate.

- When the MOSFET is off there is a barrier between the length of S and D due to depletion layer of negative ions in respect to p-substrate/n-doped region on both sides.
- There is no current flowing through the gate. It is just used for biasing the capacitor region.
- The channel acts like a resistor hence more length causes to have more resistance and more width (acts like multiple parallel resistance) causes decrease in resistance.
- Higher the gate voltage the less the resistance for the channel (due to more accumulation of electrons in the channel).
- When the drain voltage is equivalent to the voltage in the D-G junction, i.e. ($V_{GD} – V_{TH}$) the channel offers the least resistance.
- The V-I characteristic is parabolic towards the V axis for different gate voltages.

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