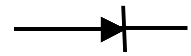
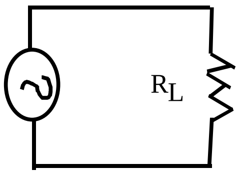
AC CIRCUITS - Applications

Diodes - allow the current to pass one way only. The symbol for a diode is

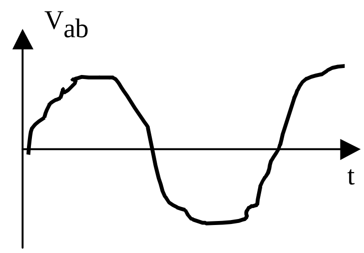


The arrow specifies the allowed direction of the current.

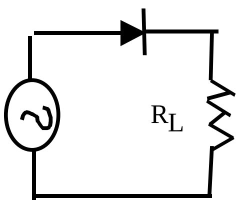
Consider the ac circuit shown below:



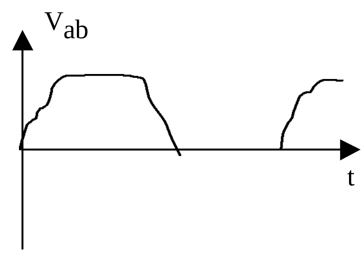
-the current here flows both ways -



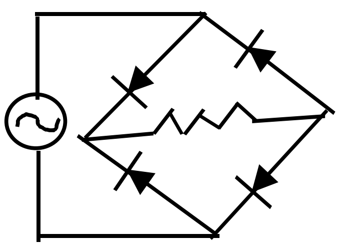
If we now include a diode in the circuit since current is allowed to flow only one way the voltage V_{ab} takes only positive values.



- the current flows only one way
- and exists only for half the cycle.
- Thus a 'half-wave' rectifier.

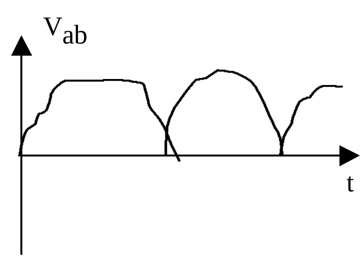


A full wave rectifier can be constructed by using four diodes as shown in the figure below. You can verify that the current through the load flows in the same direction both during the positive half of the cycle and the negative half.

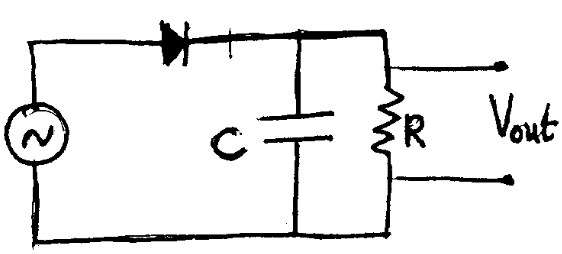


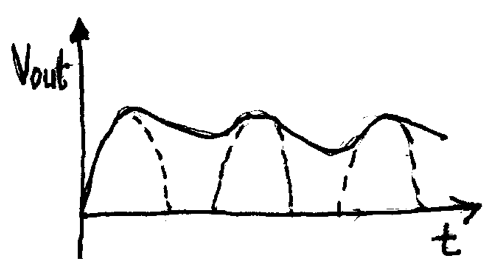
- Gives output as -

This is a full wave rectifier.



Filters: Although the voltage across the load now exists at all times it is not steady. The ripple seen can be removed by using a 'filter'- in this case a low pass filter.

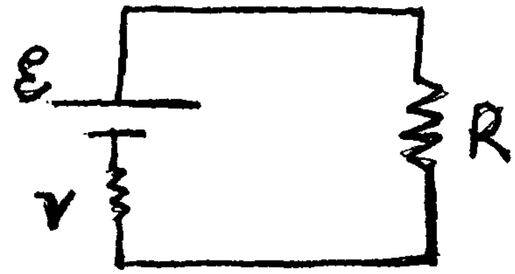




Consider the parallel RC combination with a diode as shown in the diagram. The voltage across the resistor is given by:

$Vout = I.\left(\frac{1}{wC}\right) = I.R$. Clearly the high frequency parts are shorted out and only the 'dc' or low frequency part appears across the resistor.

Impedance Matching: refers to the ability to deliver power efficiently. For instance consider the simple dc circuit shown below - a battery with emf E and internal resistance r delivers current to a load resistor R.



When is the most power dissipated in R ?

$P = I^2 R$ is this large when R > r or when R < r?

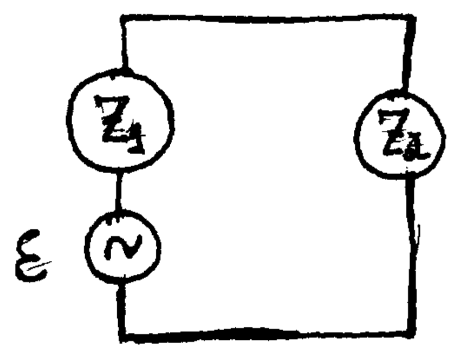
Since $I = \frac{E}{(R+r)}$ we can write

$P = \frac{E^2 R}{(R+r)^2}$ Thus for both R >> r and R << r the power P is small. Hence we can suspect that at some intermediate R the power is a maximum. The condition for maximum P is:

$$\frac{\partial P}{\partial R} = 0 = \frac{E^2}{(R+r)^2} - \frac{2E^2 R}{(R+r)^3}$$

This gives $\left(1 - \frac{2R}{(R+r)}\right) = 0 \Rightarrow r - R = 0$ or R=r

Similarly in the case of the ac circuit shown below :



The average power delivered to Z_2 will be:

$\langle P \rangle = \frac{E^2{}_{rms}}{Z^2{}_{total}} R_2$ because only the 'R' part dissipates power.

Here Ztotal is given by (assuming series connections):

$$Z_{total} = \sqrt{\left[\left(X_{L1} + X_{L2}\right) - \left(X_{C1} + X_{C2}\right)\right]^2 + (R_1 + R_2)^2}$$

Thus <P> is maximized when Z total isminimized or when the reactances cancel. This means that:

$\left(X_{L1} + X_{L2}\right) = \left(X_{C1} + X_{C2}\right)$ or $\left(X_{L1} - X_{C1}\right) = -\left(X_{L2} - X_{C2}\right)$ and when R1=R2.