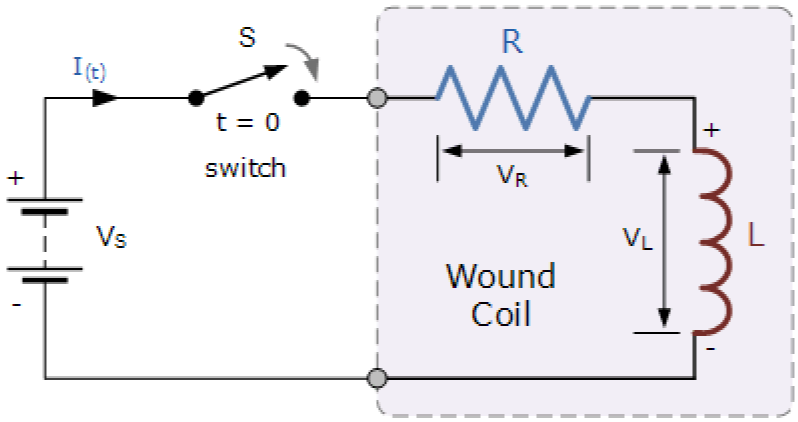
Series R-L Circuit:

Majority of coils that you see in the real world, whether they are solenoids, relays or any other similar component always exhibit certain amount of resistance because the copper wire has a resistive value. In such a case, the simple coil can then be considered as an Inductance in series with a resistance. This may be termed as the **RL Series Circuit**.
We have shown the RL Circuit in the figure given below. The circuit basically consists of an inductor of inductance L connected in series with a resistor of resistance R. This 'R' is the DC resistive value of the loops that is utilized in the preparation of the coil of the inductor.

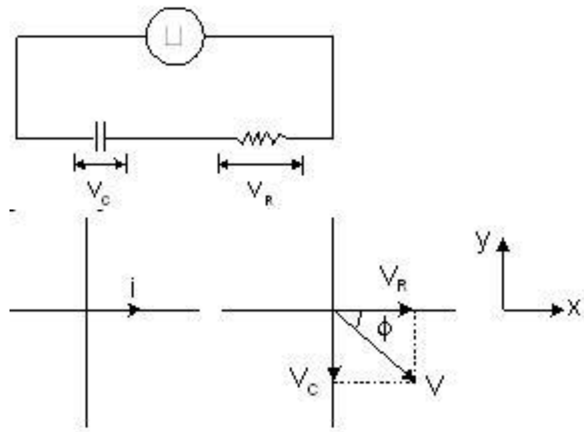


As it is visible form the figure above, the circuit is attached to a battery and switch. The switch 'S' is assumed to be open till it is closed at time t = 0. It will then remain constantly closed thus producing a "step response" type voltage input. The current 'i' though flows through the circuit, but will not rise to its maximum value of Imax.

This restriction is basically due to the existence of the self-induced emf inside the inductor due to the growth of magnetic flux. After some time, the influence of the self- induced emf is nullified by the voltage source. The flow of current then becomes constant and the induced current and field are reduced to zero.

Series R-C Circuit:

Potential difference across a capacitor in ac lags in phase by 90° with the current in the circuit. Suppose, in phasor diagram current is taken along positive x-direction. Then VR is also along positive x-direction but VC is along negative y-direction. So we can write



$V = V_R - jV_C = iR - j(iX_C)$

$= iR - j\ (1/\omega C)$

$= iZ$

Here, impedence is given by

$Z = R - j\ (1/\omega C)$

The modulus of impedance is,

$|\ Z\ | = \sqrt{R^2 + (1/\omega C)^2}$

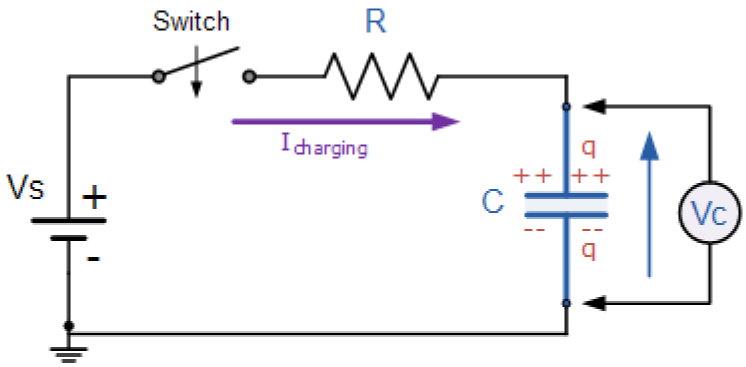
Also, the potential difference lags the current by an angle,

$\Phi = \tan^{-1} |\ V_C/V_R| = \tan^{-1} X_c/R = \tan^{-1}\{(1/\omega c)/\ R\}$

Hence, $\Phi = \tan^{-1}(1/\omega CR)$.

Let us now discuss the R-C circuit in detail:

The figure below shows a capacitor, (C) in series with a resistor, (R) forming a **RC Charging Circuit** connected across a DC battery supply via a mechanical switch. Once the switch is closed, with the help of the resistor, the capacitor gradually gets charged till the voltage across it reaches the supply voltage of the battery. The whole process of the charging of capacitor is depicted below.

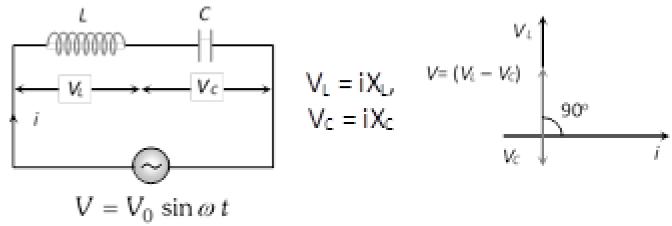


Suppose that the capacitor (C) is fully discharged and the switch (S) is fully open. These are the initial conditions of the circuit when t =0, i=0 and q=0. The time commences when t=0 and it is then that the current begins to flow into the capacitor through the resistor. But the initial voltage (V_C =0) of the capacitor is zero which forces the capacitor to appear as a short circuit and the maximum flow of current through the circuit is restricted by the resistor R. The current not flowing around the circuit is called the **Charging Current** and is calculated with the help of Ohms law.

Remarks:

- **Impedance:** The total measure of opposition to electric current is called as impedance. It is in fact the vector sum of real resistance and imaginary resistance.
- Impedance is denoted by Z and is managed just like resistances R in series circuits.
- $Z_{Total} = Z_1 + Z_2 + \ldots Z_n$, so the series impedances add to form the total impedance. All the calculations involved in this should be performed in complex form and not in scalar form.
- When resistors and capacitors are mixed together in circuits, the total impedance will have a phase angle somewhere between 0° and -90°.
- The fundamental properties of Series AC circuits and series Dc circuits are the same. Current is uniform throughout the circuit, voltage drops add to form the total voltage, and impedances add to form the total impedance.

Series LC Circuit:



(1) Applied voltage :

$$V = V_L - V_C$$

(2) Impedance :

$$Z = X_L - X_C = X$$

(3) Current :

$$i = i_0 \sin(\omega t \pm \frac{\pi}{2})$$

(4) Peak current :

$$i_0 = \frac{V_0}{Z} = \frac{V_0}{X_L - X_C}$$

$$= \frac{V_0}{\omega L - \frac{1}{\omega C}}$$

(5) Phase difference :

$$\varphi = 90^o$$

(6) Power factor :

$$\cos\phi = 0$$

(7) Leading quantity : Either voltage or current

Circuit Elements with AC:

Circuit elements	Amplitude relation	Circuit quantity	Phase of V
Resistor	$V_0 = i_0 R$	R	In phase with i
Capacitor	$V_0 = i_0 X_C$	$X_c = \frac{1}{\omega C}$	Lags i by 90°
Inductor	$V_0 = i_0 X_L$	$X_L = \omega L$	Leads i by 90°