PARALLEL RLC CIRCUIT ANALYSIS

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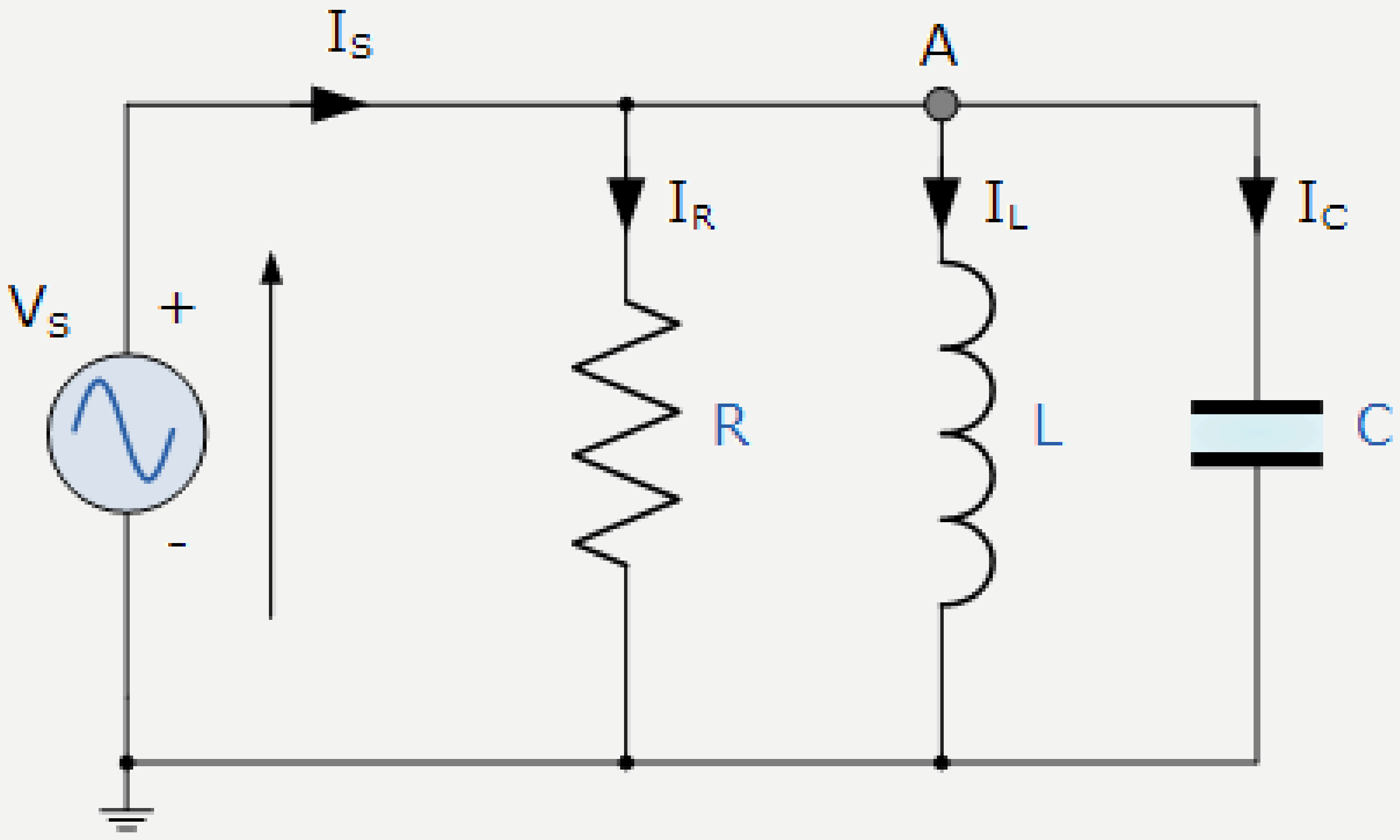
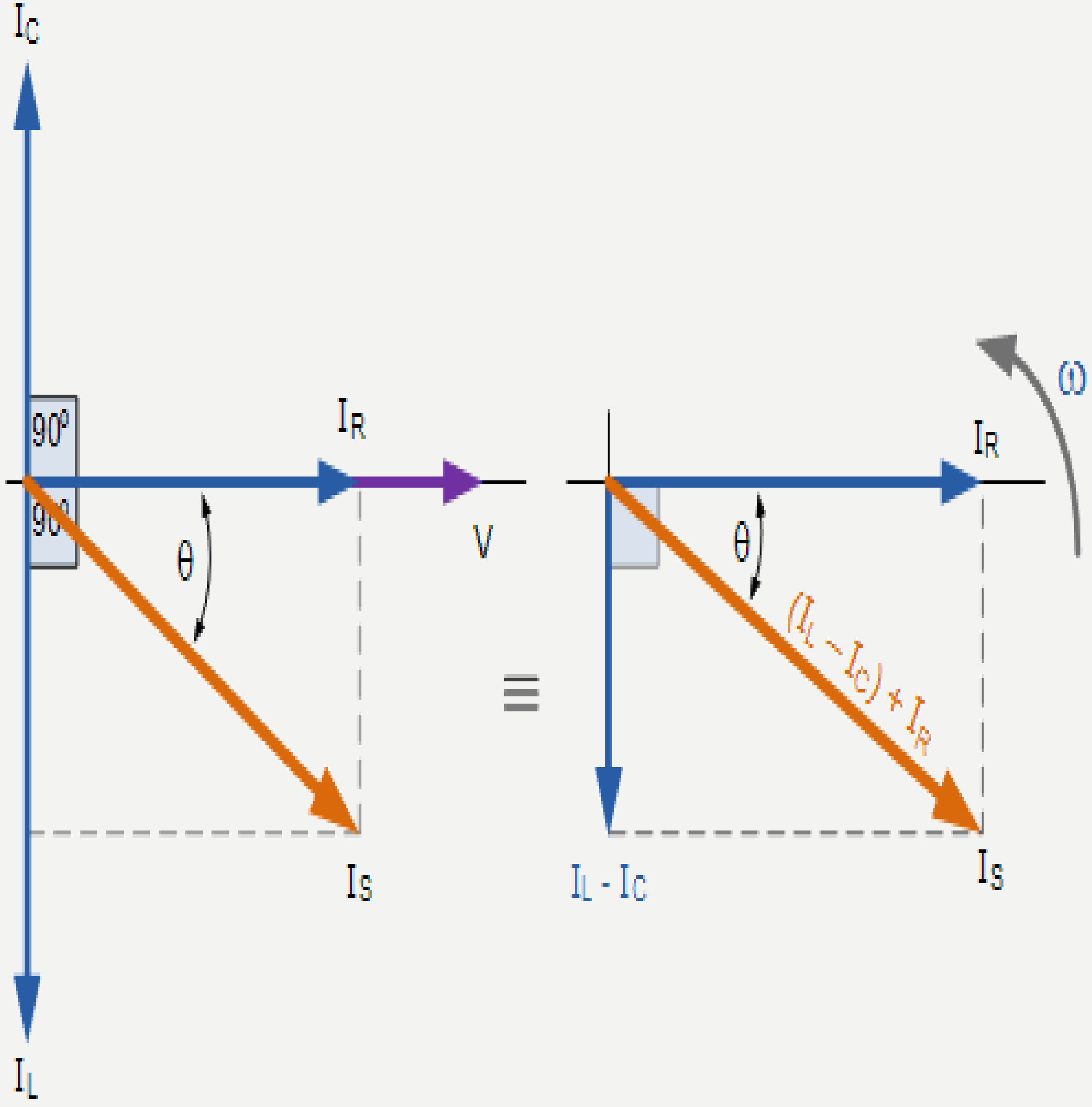


Is
A
IR
IL
IC
Vs
+
-
R
L
C

In the above parallel RLC circuit, we can see that the supply voltage, VS is common to all three components whilst the supply current IS consists of three parts. The current flowing through the resistor, IR, the current flowing through the inductor, IL and the current through the capacitor, IC.

But the current flowing through each branch and therefore each component will be different to each other and also to the supply current, IS. The total current drawn from the supply will not be the mathematical sum of the three individual branch currents but their vector sum.



We can see from the phasor diagram on the right hand side above that the current vectors produce a rectangular triangle, comprising of hypotenuse IS, horizontal axis IR and vertical axis IL – IC Hopefully you will notice then, that this forms a Current Triangle. We can therefore use Pythagoras's theorem on this current triangle to mathematically obtain the individual magnitudes of the branch currents along the x-axis and y-axis which will determine the total supply current IS of these components as shown.

Current Triangle for a Parallel RLC Circuit

$$I_S^2 = I_R^2 + \left(I_L - I_C\right)^2$$

$$I_S = \sqrt{I_R^2 + \left(I_L - I_C\right)^2}$$

$$\therefore \; I_S = \sqrt{\left(\frac{V}{R}\right)^2 + \left(\frac{V}{X_L} - \frac{V}{X_C}\right)^2} = \frac{V}{Z}$$

where: $I_R = \dfrac{V}{R}, \quad I_L = \dfrac{V}{X_L}, \quad I_C = \dfrac{V}{X_C}$

Impedance of a Parallel RLC Circuit

$$R = \frac{V}{I_R} \quad X_L = \frac{V}{I_L} \quad X_C = \frac{V}{I_C}$$

$$Z = \frac{1}{\sqrt{\left(\frac{1}{R}\right)^2 + \left(\frac{1}{X_L} - \frac{1}{X_C}\right)^2}}$$

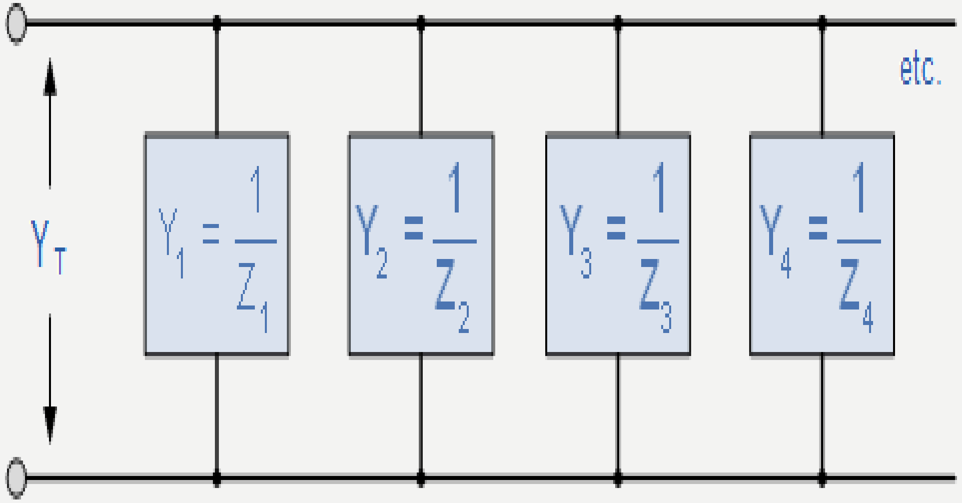
$$\therefore \frac{1}{Z} = \sqrt{\left(\frac{1}{R}\right)^2 + \left(\frac{1}{X_L} - \frac{1}{X_C}\right)^2}$$

The final equation for a parallel RLC circuit produces complex impedance's for each parallel branch as each element becomes the reciprocal of impedance, (1/Z). The reciprocal of impedance is commonly called Admittance, symbol (Y).

In parallel AC circuits it is generally more convenient to use admittance to solve complex branch impedance's especially when two or more parallel branch impedance's are involved . The total admittance of the circuit can simply be found by the addition of the parallel admittances. Then the total impedance, Z of the circuit will therefore be 1/Y Siemens as shown.

Admittance of a Parallel RLC Circuit

$$\frac{1}{Z_T} = Y_T = Y_1 + Y_2 + Y_3 + Y_4 + \ldots\ldots etc$$



The unit of measurement now commonly used for admittance is the Siemens, abbreviated as S, (old unit mho's ℧, ohm's in reverse). Admittances are added together in parallel branches, whereas impedance's are added together in series branches. But if we can have a reciprocal of impedance, we can also have a reciprocal of resistance and reactance as impedance consists of two components, R and X. Then the reciprocal of resistance is called Conductance and the reciprocal of reactance is called Susceptance.

Admittance (Y) :

Admittance is the reciprocal of impedance, Z and is given the symbol Y. In AC circuits admittance is defined as the ease at which a circuit composed of resistances and reactances allows current to flow when a voltage is applied taking into account the phase difference between the voltage and the current.

The admittance of a parallel circuit is the ratio of phasor current to phasor voltage with the angle of the admittance being the negative to that of impedance.

Resonance in Parallel RLC Circuit

Like series RLC circuit, parallel RLC circuit also resonates at particular frequency called resonance frequency i.e. there occurs a frequency at which inductive reactance becomes equal to capacitive reactance but unlike series RLC circuit, in parallel RLC circuit the impedance becomes maximum and the circuit behaves like purely resistive circuit leading to unity electrical power factor of the circuit.